



# CALIFORNIA STATE MINING BUREAU.

---

## THIRD ANNUAL REPORT

OF THE

# STATE MINERALOGIST

FOR THE YEAR ENDING JUNE 1, 1883.



SACRAMENTO:

STATE OFFICE, . . . . . JAMES J. AYERS, SUPT. STATE PRINTING.

1883.

LIBRARY

UNIVERSITY OF CALIFORNIA

DAVIS



*To his Excellency* GEORGE STONEMAN, *Governor of California:*

Sir: I have the honor herewith to submit to you the third annual report of the State Mineralogist of California, in compliance with section three of an Act of the Legislature, entitled "An Act to provide for the establishment and maintenance of a Mining Bureau," approved April 16, 1880.

I have the honor to be, very respectfully,

HENRY G. HANKS,  
State Mineralogist.

SAN FRANCISCO, June 1, 1883.





## REPORT OF THE STATE MINERALOGIST.

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The California State Mining Bureau was created by an Act of the twenty-third Legislature, approved April 16, 1880. The first section of the Act provides for a principal office in the City of San Francisco "in which there shall be collected and preserved for study and reference all the geological and mineralogical substances—including mineral waters—found in the State." The same section further provides for a collection of minerals, rocks, and fossils of other States, Territories, and countries, to be at all reasonable hours open for public inspection, examination, and study.

Section three provides for a library of works on mineralogy, geology, and mining, a collection of models and drawings of mining and milling machinery used in the reduction of ores, and directs the opening of correspondence to obtain information respecting improvements in mining machinery of practical value to the people of the State. The State Mineralogist is instructed to visit the several mining districts, to ascertain and record their history, and to describe their geology and the ores they produce. At the close of the year he is directed to report in detail to the Governor. By section four the State Mineralogist is allowed to appoint assistants when the condition of the funds will permit. All other provisions are secondary and subservient to the Museum, which is made the principal feature of the institution.

The full text of the Mining Bureau Act was published in the first report of the State Mineralogist, December 1, 1880.

Since the second and last report, October 1, 1882, a fair progress may be reported.

The Mining Bureau still occupies the premises No. 212 Sutter Street. Important and valuable additions have been made to the Museum, a considerable portion of which have been catalogued and placed in the cases. The actual number of Museum specimens entered since the last report, is 1,065, and the total number in the catalogue, 5,212. There is as yet no catalogue of the books, of which many have been received during the year.

The following is a list of names of donors, whose contributions have been entered in the catalogue. Others will be published in the next report. Some of the donors have made a number of gifts, although the name appears but once in the list. When the new catalogue is published full credit will be given for each specimen presented. The donations to the Museum and Library have been of unusual interest, and many of them of great value.

## LIST OF DONORS.

- Abbott, Henry,  
Alderman, E. M.,  
Aldrich, H. A.,  
Alexander, A. M.,  
Allen, C. F.,  
Amick, M. J.,  
Attwood, Melville,  
Ayres, William,  
American Museum of Natural History.
- Ballarat School of Mines,  
Balser, George,  
Barnard, John Kirk,  
Barnes, Edward,  
Basse, Louis,  
Bassett, William D.,  
Battursby, Captain,  
Beardsley, George F.,  
Behrens, James,  
Bilty, Theodore G.,  
Bluxome, Isaac,  
Booth, Edward,  
Borden, R. V.,  
Boyd, Mrs.,  
Briggs, Rev. Mr.,  
Brown, Charles W.,  
Brown, William, Jr.,  
Brumagim, J. W.,  
Buckingham, N. D.,  
Burchard, Horatio C.,  
Burke, Morris,  
Bush, Mrs. A. E.,  
Buswell, Alexander,  
Butler, J. H.
- Cain, J. W.,  
Caldwell, H. M.,  
California State Geological Society,  
Carmany, J. H.,  
Casaneuva, F.,  
Casarello, J.,  
Cherry, William,  
Cincinnati Society of Natural History,  
Clark & Son,  
Clarke, William,  
Classen, J. M.,  
Cohen, Richard,  
Cole, A. M.,  
Colerick, J. K.,  
Collins, S. W.,  
Comstock, Charles H.,  
Connelly, T. F. A.,  
Cooledge, C. C.,  
Cook, Prof. George H.,  
Cooke, J.,  
Cooper, Ellwood,  
Cresswell, John,  
Cresswell, Mrs. John,  
Crossman, J. H.,  
Culver, J. H.,  
Currie, William.
- Daggett, Hon. John,  
Dana, A. W.,  
Daunet, I.,  
Davenport Academy of Sciences,
- Davies, P.,  
Davis, J. Z.,  
Day, Mrs. H. H.,  
DeBegon, L.,  
Decker, Peter,  
DeGoha, A. W.,  
Department of the Interior, U.S.,  
Donough, T.,  
Donnelly, Dr. E.,  
Dorman, Levi,  
Drake, Frank,  
Dunn, R. L.,  
Durden, H. S.
- Edman, J. A.,  
Eger, Dr. L.,  
Eleau, H.,  
Elliott, Andrew,  
Ellis, John E.,  
Elwyn, F.,  
Emersley, J. D.,  
Emerson, George W.,  
Everett, T. B.,  
Ewing, Thomas.
- Farrington & Moss,  
Faulhaber, Carlos,  
Fay, Caleb T.,  
Febiger, C.,  
Figel, Philip I.,  
Figg, E. P.,  
Figuera, L.,  
Folingsby, T. H.,  
Fracker, A. H.,  
Friend, Charles W.,  
Frost, C. W.
- Galbreath, R. H.,  
Gallagher, Edward A. T.,  
Gallagher, Frank,  
Gascoyne, W. J.,  
Gates, Harry,  
George, Arthur T.,  
George, Dr. S. G.,  
Gilmore, Thomas,  
Gladding, McBean & Co.,  
Glass, Louis,  
Gorley, Captain H. A.,  
Gould, James,  
Graham, J. M.,  
Green, H.,  
Green, J. C.,  
Griffin, J. B.,  
Griffin, Thomas,  
Grigsby, R. F.,  
Gutzkow, Fr.
- Haggin, J. B.,  
Haher, E. C.,  
Hain, E.,  
Hanks, H. G.,  
Hartley, H. H.,  
Hartson, Hon. C.,  
Harvey, Dr. Philip,  
Hawes, G. H.,  
Hawkshurst, H.,  
Hazen, General William B.,  
Heald, E. P.,  
Hearn, Dr. F. G.,
- Heverin, M.,  
Heydenfeldt, S., Jr.,  
Hittell, John S.,  
Hoitt, J. S.,  
Holcombe, S. E.,  
Holmes, A. J.,  
Holt, W. H.,  
Howe, H. M.,  
Hughes, Dr. C. B.,  
Hulford, E. W.,  
Hunter, Thomas G.,  
Hyde, H. C.
- Johnson, J. F.,  
Jones, Dr. William.
- Kaufman, Charles,  
Keeler, Hon. J. M.,  
Keeney, G. D.,  
Keep, Col. Albert,  
Keep, Mrs. A.,  
Kennedy, Ed.,  
Kimble, George W.,  
Knapp, C. R.,  
Knox & Osborn.
- Landis, John,  
Lawton, W. S.,  
Leary, John,  
Linton, W. D.,  
Liversidge, Prof. A.,  
Lombard, J. W.,  
Loomis, J. W.
- MacKillican, D. R.,  
Manning, J. G.,  
Manter, J. R.,  
Marcou, Jules,  
Marcus, Morris,  
Marriotte, Noel,  
Martin, E. W.,  
Martin, G. W.,  
Mason, W. B.,  
May, Henry,  
Maynard, H. G.,  
McDougal, W. C.,  
McGrew, William K.,  
Mercantile Library Association,  
Merrill, F. H.,  
Minister of Mines, B. C.,  
Mintzer, William H.,  
Monteverde, F. E.,  
Montgomery, Zach.,  
Moody, W. H.,  
Moraga, J. C.,  
Morales, A.,  
Morgan, D. W. C.,  
Moss, Joshua,  
Munroe, Prof. Charles E.,  
Murdock, W. B.,  
Murray, Welwood.
- Nichols, George.
- Oakland Gold Mining Company,  
Ogg, C.,  
Oregon Iron Company,  
Osborn, H. E.,  
Osborn, Joseph.

Parker, James E.,  
 Paul, A. B.,  
 Peck, W. H.,  
 Perkins, Henry C.,  
 Peticolas, C. L.,  
 Philips, George K.,  
 Pillsbury, Charles J.,  
 Porter, W. H.,  
 Pownall, J. B.,  
 Price, Col. E. H.,  
 Price, Edward M.,  
 Putnam, Mr.

Quayle, William.

Ramsey, Prof. Alexander,  
 Randall, William H.,  
 Randol, J. B.,  
 Raymond, W. H.,  
 Rhodes, John,  
 Roberts, A. E.,  
 Roberts, E. W.,  
 Robinson, William,  
 Rosecrans, General,  
 Rowley, A. B.,  
 Russell, B. D.,  
 Russell, D.,  
 Ryan, J. F.

Sarvis, George C.,  
 Schaeffle, E. H.,  
 Scott, Chalmers,  
 Scupham & Childs,  
 Scupham, J. R.,  
 Sellers, Charles,  
 Sheerer, Joseph,  
 Shepard, Prof. C. W.,  
 Silver, Lowry,  
 Sime, William K.,  
 Skellings, E. M.,  
 Skinner, M.,  
 Sletcher, F.,  
 Smith Bros.,  
 Smith, F. W.,  
 Stanley, W. H.,  
 Stearns, Robert E. C.,  
 Stokes, W. C.,  
 Stone, Charles S.,  
 Stone, Dudley C.,  
 Stout, Dr. A. B.,  
 Stoutenborough, J. H.,  
 Szabo, Dr. Joseph.

Tagleblue, Frank,  
 Tanner, Mrs. J. G.,  
 Thomas, R. P.,  
 Toomey, M.,

Townsend, Mrs.,  
 Truett, M. F.,  
 Tryel, Mr.,  
 Tyler, Charles M.

Union Pacific Salt Company.

Walkinshaw, Robert,  
 Ward, H. H.,  
 Ward, W. E.,  
 Wasson, Hon. Joseph,  
 Waterman, J. S.,  
 Weir, J. C.,  
 White, D. Morgan,  
 White, Mrs. J. S.,  
 Williams, Albert, Jr.,  
 Williams, Blanchard & Co.,  
 Williams, Col. A. F.,  
 Williamson, Col. R. S.,  
 Wilson, George R.,  
 Wilson, J. F.,  
 Wilson, W. H.,  
 Winterburn,  
 Woodhull, S. D.,  
 Woodley, W. J.,  
 Worcester Royal Porcel'n W'ks,  
 Wymant, N.,  
 Young, W. W.

The following newspapers have been sent to the Mining Bureau gratuitously:

1. Engineering and Mining Journal, New York.
2. Mining Record, New York.
3. Mining Review, Chicago, Illinois.
4. Economist, Boston, Massachusetts.
5. Daily Report, San Francisco.
6. Daily Transcript, Nevada City, Nevada County, California.
7. Grass Valley Union, Nevada County.
8. Sierra County Tribune.
9. Democratic Standard, Eureka, Humboldt County, California.
10. Inyo Independent, Inyo County.
11. Reno Evening Gazette, Reno, Nevada.
12. Arizona Gazette, Phoenix, Arizona.

#### LIBRARY.

The increase of the library has been principally by donation—a few indispensable volumes only have been purchased. The library of the State Mining Bureau should contain all standard scientific works and books of reference, specially those bearing on mining, metallurgy, chemistry, mineralogy, geology, paleontology, etc., and publications of scientific societies at home and abroad. These works should always be accessible to those who wish to study, but never be taken from the rooms.

#### PUBLICATIONS.

The State Mining Bureau has made two reports, and published the First Annual Catalogue of the State Museum. For reasons set forth, they were not issued at regular intervals, but are equivalent to annual reports. The dates of the publications are as follows:

First Report, from June 1 to December 1, 1880; forty-three pages.

Second Report, from December 1, 1880, to October 1, 1882; five hundred and fourteen pages.

First Annual Catalogue of the State Museum of California, for the year ending April 16, 1881; three hundred and fifty pages.

Of the first report a second edition was ordered printed by joint resolution of the Legislature. Both editions of the First and the whole of the Second Report have been distributed; a few copies of the Catalogue remain.

Owing to inexperience and want of proper assistance, the Second Report was defective in being without an index, which has been as far as possible remedied by the printing of an index and a correction sheet, which will be furnished to those having copies of the report, upon application. A few copies of the Second Report were reserved until photographs showing the modes of hydraulic mining in California could be prepared. Copies of the illustrated report have been sent to the Secretary of State of every State and Territory in the Union and to the principal Governments of the world.

With this, the Third Annual Report, a second part has been prepared, entitled:

"A Report of the Borax Deposits of California and Nevada, giving the Production, Consumption, Uses, History, Chemistry, and Mineralogy of Boracic Acid and its Compounds, and other General Information, with a Map showing the Principal Localities in the Two States," which is the sixth of a series of papers on the principal natural products of California; *Hydraulic Mining*, *Forest Trees*, *Diatomaceous Earths*, *Diamonds*, and *Salt* having been specially treated in the Second Report.

#### LABORATORY WORK.

The importance of complete analyses of ores, minerals, mineral waters, building stones, rocks, limestones, cements, fertilizers, etc., laboratory experiments bearing on the working of complex ores, and a careful study of low grade ores, and those requiring concentration, is fully realized by the State Mineralogist; and a course of such work was early planned, the results of which it was hoped would form an interesting and important part of the annual reports.

But, owing to the forced closing of the laboratory and discharge of the Chemist, there is but little chemical work to report. Many examinations of minerals have been made by the State Mineralogist personally, and information sent to those asking it, but this class of work has not been done to the extent it should be, for reasons set forth in this and preceding reports. A number of analyses of coal from newly discovered localities, and of ores and minerals, in a few cases, have been made; but the meager results have been reserved for future publication. The results of considerable study of the borax minerals of the State appear in Part Second of this report.

## FINANCIAL CONDITION OF THE MINING BUREAU.

## CALIFORNIA STATE MINING BUREAU.

*Receipts and Expenditures from September 1, 1882, to June 1, 1883.*

Postage-----	\$43 85	Mining Bureau fund-----	\$1,882 20
Museum expense-----	8 55	Wells, Fargo & Co. advances---	1,205 05
General expense-----	2,190 70		
Maps-----	7 00		
Salaries-----	733 70		
Library-----	9 00		
Traveling expense-----	63 90		
Cash on hand-----	30 55		
Total-----	\$3,087 25	Total-----	\$3,087 25

*Amount paid into Mining Bureau Fund and retained by State Treasurer pending the Auditing of Accounts of Mining Bureau.*

April, 1883----- \$522 65

*Expenses incurred, but not paid, from September 1, 1882, to June 1, 1883.*

General expense-----	\$484 80
Salaries-----	600 00
Total-----	\$1,084 80

The books of the Mining Bureau show a deficiency of \$3,864 for the three years, which has been advanced from time to time by Wells, Fargo & Co. For this there are vouchers, showing that the amount has been economically expended. These vouchers have been examined by the State Board and found correct, but have not been allowed, because the law provides that the expenditures shall not exceed in any year the income for that year, but no provision was made in the law to meet the emergency caused by the rapid diminution of the fund. Every economy has been practiced to make the expenses as small as possible without actually closing the Museum, which the law directs shall be kept open. Messrs. Wells, Fargo & Co. have not only advanced money to the institution, but have delivered a multitude of packages free, and have extended many favors for which the State owes them a debt of gratitude.

When the Mining Bureau first commenced operations the fund for its support was ample. During the next twenty-two months, up to the publication of the Second Report, the income gradually diminished until the last quarter, during which it fell to the monthly average of \$542 66, upon which it was impossible to support the institution. The deficiency was made up, as before stated, by advances by Wells, Fargo & Co., without which the institution would have been compelled to close its doors at a time when its usefulness and importance were admitted, not only by the citizens of our own State, but by those of Eastern States and foreign countries.

It then became apparent that it was a mistake to appropriate an uncertain sum for the support of a noble State institution; it would have been much better to set aside a fixed amount, even if it had been smaller, and to have allowed the tax transfer fund to revert again to the State Treasury. The latter, however, being the only support of the institution, great inconvenience followed its diminution.



By dispensing with the services of a Secretary, and for a time with those of a Janitor, it was planned to return to Wells, Fargo & Co. the advances made by them, from the savings. But the decision of the Board of Examiners made this impossible. There is no doubt in my mind that the next Legislature will provide for the deficiency by a special Act.

The Legislature of 1881 was asked to make some provision for the Mining Bureau, which was recommended by the Governor in his message, but while that body showed a disposition to do so the effort failed for reasons well known, and it was found, in the extra session which followed, that no appropriation could be made without amending the original Act, which could not be done at an extra session. In the month of February, 1882, the State Mineralogist wrote to the Governor, stating the decrease of the Mining Bureau Fund, and informing him that it would be impossible to maintain the efficiency of the institution on the income, since which time he has been compelled to practice the utmost economy without sacrifice to the interests of the State, and has tried to accomplish personally as much as possible of the labor of the different departments, to the best of his ability.

It was thought best to keep the museum open until the meeting of the following Legislature, the more so as it was found that it could not be closed without incurring considerable expense, and as the replacing of the museum material would entail considerable loss to the State.

A bill was introduced in the Senate asking for an appropriation of \$11,000 yearly, for two years, which was reduced by that body to \$5,000 per annum, in which form it became a law. The reduction was made by the Senate committee, on the assumption that the tax transfer fund would not fall below that of the quarter preceding their visit to the bureau, which was about \$1,700, or \$540 per month; but it has continued to decrease, and there is reason to believe that it will diminish indefinitely. It is the experience made by the management, that the original Mining Bureau Fund cannot be depended upon, and should not be taken into future calculations. It is collected three months after it has accrued, and, as the institution was started three months before any money was paid in to its credit, the fund for six months is a part of the assets and must be used in the payment of expenses due.

To close the museum, even for a year, would be to take a step backward; and, while it would not, perhaps, otherwise impair the usefulness of the Mining Bureau, such a retrograde movement would entail a loss, not only as regards the labor expended in bringing the museum to its present state of perfection, but to this must be added the cost of packing, and the labor requisite when it was again opened. To allow the museum in this advanced state to close would be almost as serious a mistake as the discontinuance of the Geological Survey, which has always been a regret to thinking citizens. Many persons have donated largely to the State Museum with the understanding that their contributions should be cared for by the State and kept on permanent exhibition. It would not be keeping faith with them if their valuable gifts should be hidden away for an indefinite period, and it would be a shame now to hide all the beautiful and valuable specimens which have been acquired.

The State Museum has only been brought to its present condition

by much labor and no inconsiderable expense. As now arranged it will compare favorably with those of other countries, according to the verdict of many persons who have visited similar institutions both at home and abroad; yet there are other specimens on hand, classified and arranged, in sufficient numbers to double those now on exhibition. They are packed in boxes in another room, and await the purchase of cases for their display. The specimens already in the museum are crowded for want of case room. They should occupy from six to ten cases more, to show them to the best advantage. This could be easily and quickly done if the money was forthcoming to pay for the extra cases. The boxed specimens could also be displayed within a month if the necessary funds were provided.

This is not the first effort that has been made to establish a State Museum of Geology and Mineralogy in California. The legislative Act which created the Geological Survey made it the duty of the State Geologist "to collect the rocks, fossils, soils, and minerals of the State, and its zoölogical and botanical productions, to be deposited in such place as should thereafter be provided for that purpose by the Legislature;" but such provision was never made, and the valuable collections of the survey were stored in a warehouse which was destroyed by fire. Thus a great loss was sustained by the State. Professor Whitney, in a lecture in the City of San Francisco in 1864, called attention to the importance of a State Museum, and it was not his fault that the plan was not carried out.

The success of the Mining Bureau Museum proves that such an institution is wanted by the people. In no other country could so large and varied a collection be made in so short a time, for in no other country are so many prospectors interested in having ores and minerals they discover placed on exhibition. The collection, with the library and other State property, is certainly worth more than the cost of the institution. The whole of the property acquired up to the present time has been derived from the mining community, but it now belongs to the State. This should be a consideration for other classes, who are equally benefited, to come forward and assist in making the State Museum the great institution it deserves to be.

The founding of museums for education and display of national resources, is almost universal, and it is not to be supposed that the whole world is mistaken, or has been in the past.

What applies to other countries applies equally to California, for if there is any State that needs to show up her natural resources it is California; for she has long invited capital from abroad, and begins to wonder why her population is so small while her natural advantages are so great.

To the average inhabitant of the earth our State is either wholly unknown, or is regarded as a vast region of desert lands, valuable only for the mines of gold and silver found in them. Even men of education and science make serious mistakes in regard to California; as, for instance, in Dana's Geology, which is considered a standard work on that subject, it may be found stated that "chrome iron occurs in the serpentines of California, but not in a condition to repay mining;" while, on the contrary, that important and scarce mineral is largely mined and exported.

There have been so many mistakes regarding the character of our mining districts, and so many misstatements to those who have been asked to invest their capital in California, that there is need of an



official source of information relating to the varied resources of the State. This can best be accomplished by granting to the institution already established a liberal support.

The Mining Bureau was located at San Francisco because it was thought that the museum would be more accessible to the people of the State generally. It has already been of benefit to the city, and can be made more so if it meets with the encouragement it deserves.

Both Arizona and Colorado are considering the establishment of a State Mining Bureau on a similar plan as ours, and a national association has been organized, the object of which is, in part, to encourage State Museums. The State of New York gave its credit, and appropriated \$3,500 per annum as interest on the sum required for the museum buildings in Central Park, and a further amount of \$500,000 for equipping and furnishing the same, to which the citizens have also largely contributed.

St. Louis has recently subscribed \$483,000 for a building for similar purposes.

In the encouragement of a State Museum in which all the natural resources of the State should be placed on permanent exhibition, San Francisco should take the most active part, because she has received the compliment of having the Mining Bureau placed within her limits.

While the institution has been called the "Mining Bureau," and so far, has been paid for by the miners, its usefulness has been general, and the merchant, manufacturer, and the agriculturist are, or should be, deeply interested in its success.

In order to manufacture to advantage, crude material must be both abundant and cheap, and, as far as possible, should be found within the State borders. It is now known that gold and silver are not the only metals in the State worthy of attention, but that other ores having an economic value are abundant. Many such instances have been made known through the agency of the State Mining Bureau. It ought not to be true that we waste enough in California to make the entire population comparatively rich.

The Mining Bureau has grown out of all proportion to the provision made for its support, and quite beyond the expectations of its friends; but the management now finds itself in the anomalous position of being compelled to retard its progress rather than to push it forward.

It has long been evident that the State Museum was becoming too extensive and valuable to be managed by a single individual. The experience of the last three years has shown that there is a great future for the institution, if properly managed, and it is well worthy of the fostering care of the State. But it has already become so extended in its scope that no person is competent to manage it without the advice and assistance of others. Under this conviction I asked, in my last report to the Governor, "that a Board of Trustees be appointed to share the responsibility and management of the State property, leaving the State Mineralogist free to travel, to investigate and report upon new discoveries, and to conduct the scientific departments with his assistants." This was recommended by the Governor in his message, and, although no action was taken, I am still as strongly impressed with its importance as before.

It is clear to my mind that the time has come when the State Mining Bureau should be reorganized and placed on a permanent

basis, or the museum closed, and the institution and office of State Mineralogist abolished. In view of these considerations, and not wishing to bear the whole responsibility, I called a meeting of prominent citizens, asking them to act with me as an advisory committee, and to whom I set forth the above stated facts. The following letter was addressed to the gentlemen named below:

CALL MADE TO CITIZENS TO TAKE INTO CONSIDERATION THE AFFAIRS  
OF THE STATE MINING BUREAU.

CALIFORNIA STATE MINING BUREAU,  
OFFICE OF STATE MINERALOGIST,  
SAN FRANCISCO, March 23, 1883. }

DEAR SIR: You are hereby invited to meet with a number of other prominent gentlemen of this city, at the rooms of the State Mining Bureau, 212 Sutter Street, on Monday, March twenty-sixth, at three o'clock, to act as an advisory committee, to take into consideration the future of the State Museum. The matter to be laid before the committee is of great importance to the State.

Hoping that you can spare time for this purpose,  
I remain very truly,

HENRY G. HANKS,  
State Mineralogist.

CITIZENS TO WHOM THE ABOVE LETTER WAS SENT.

George C. Perkins,  
J. Z. Davis,  
George T. Marye, Jr.,  
A. B. Paul,  
C. Waterhouse,  
Cornelius O'Connor,  
Capt. J. M. McDonald,  
S. Heydenfeldt, Jr.,  
Horace Davis,  
William T. Coleman,

Mayor Washington Bartlett,  
A. Hayward,  
A. P. Brayton,  
Col. J. P. Jackson,  
Malter, Lind & Co.,  
William T. Garratt,  
John H. Carmany,  
W. B. Ewer,  
L. L. Bullock,  
Judge J. S. Hager,

H. A. Cobb,  
R. H. Sinton,  
J. M. Keeler,  
W. M. Bunker,  
Alexander Boyd,  
Robert N. Graves,  
George W. Grayson,  
Melville Attwood,  
Charles M. Tyler.

A preliminary meeting was held at the rooms of the State Mining Bureau, 212 Sutter Street, March 26, 1883. The following gentlemen were present: George T. Marye, Jr., Melville Attwood, W. M. Bunker, J. H. Carmany, William T. Coleman, J. Z. Davis, W. B. Ewer, S. Heydenfeldt, Jr., J. M. Keeler, J. M. McDonald, A. B. Paul, and Charles M. Tyler.

Mr. William T. Coleman was called to the chair, and S. Heydenfeldt, Jr., acted as Secretary. The object of the meeting was stated, and, after due discussion of the affairs of the bureau, a committee of five was appointed, consisting of Messrs. Paul, Heydenfeldt, McDonald, Bunker, and Tyler, as a Committee of Ways and Means, to devise some plan of appealing to the citizens of the State to come forward and assist in maintaining the Mining Bureau until the next session of the Legislature.

After expressing the sense of the meeting as to the value of the State Mining Bureau, and that every effort must be made to maintain its usefulness, the meeting adjourned.

A second meeting was held April sixth to receive the report of the committee, at which it was proposed to hold a PACIFIC COAST MINERAL EXPOSITION during the Triennial Conclave of the Knights Templars in August, and to appeal to the miners of the State to contribute specimens and funds to carry out that end, in the belief that the needed aid would at the same time be extended to the Mining Bureau. A new committee was formed, consisting of the following gentlemen:

Geo. T. Marye, Jr., Irving M. Scott, S. Heydenfeldt, Jr., Almarin B. Paul, Lloyd Tevis, Melville Attwood, L. L. Bullock, W. M. Bunker, William T. Coleman, James V. Coleman, C. O'Connor, Jacob Z. Davis, John Daggett, Warren B. Ewer, C. A. Hooper, W. H. Mills, J. R. Scupham, Charles M. Tyler.

The members of the committee signed the following agreement: "We, the undersigned, hereby consent to act as a committee for the purpose of encouraging an exposition of the mineral wealth of the State, and to extend the scope and usefulness of the *State Mining Bureau*."

On motion, it was decided to address the several counties of the State, the address to be prepared and submitted to the committee for consideration and approval, and that the committee be empowered to take such action in forwarding the object in view as they may consider most efficacious and suitable.

April seventeenth a meeting was called by the Secretary of the Citizens' Committee. Geo. T. Marye, Jr., was elected Chairman; Irving M. Scott, Vice-Chairman; S. Heydenfeldt, Jr., Secretary; A. B. Paul, Corresponding Secretary, and Lloyd Tevis, Treasurer. The Chairman appointed an Executive Committee, consisting of Messrs. Paul, Bunker, Heydenfeldt, Jr., and Davis; Auditing Committee—Messrs. Attwood, Bullock, and Ewer. Circular No. 1 was approved and five hundred copies ordered printed, one of which was sent to the Supervisors of each county in the State.

[Circular No. 1.]

ROOMS OF THE CITIZENS' COMMITTEE OF THE  
PACIFIC COAST MINERAL EXPOSITION,  
212 SUTTER STREET, SAN FRANCISCO. }

To the honorable Board of Supervisors of the County of ———, State of California, greeting:

We, the undersigned, a committee of citizens of the City and County of San Francisco, called by Henry G. Hanks, State Mineralogist, to consult upon the vital importance of making a grand free exposition, or display, of the mineral and material resources of the Pacific Coast, which shall be a credit and benefit to our great State and to the Pacific Coast, to be held at San Francisco during the coming Summer, when our metropolis will be filled with distinguished and influential visitors from abroad, have deemed it just and wise to address the respective Boards of Supervisors of the several counties, and through them the citizens, that no portion of the State may fail of the honor and benefit of an equal and full representation in this important and attractive display. We therefore respectfully call your attention to the reasons and considerations which have influenced the committee, viz.:

WHEREAS, The provisions made for the support of the State Mining Bureau by the Act which brought it into existence, even adding the recent legislative appropriation, are entirely inadequate for the purpose, and are insufficient for the conduct of the institution in any way commensurate with its splendid advancement and fine acquisitions of new material and valuable specimens; and whereas, the coming Summer will afford one of the great opportunities of an age for a noticeable and important free display of our mineral and material interests; and whereas, we have been impressed with the importance of so arranging the specimens that those of each county may be displayed together, an arrangement which cannot now be made for lack of cases; therefore we most respectfully lay before your honorable body the result of our deliberations, viz.:

*First*—It is proposed that the citizens of the City and County of San Francisco (and liberal-minded citizens of the State who may so desire) raise all the funds required to project and carry out a Free Pacific Coast Mineral Exposition, and make the display one of unequalled attraction and interest to all who may visit the city.

*Second*—That the respective counties, and the citizens thereof, be earnestly solicited to contribute the sum of one hundred dollars for each county—by appropriation or by private subscription—which may be sent to Lloyd Tevis, Esq., Treasurer of this Citizens' Exposition Committee, to go into what will be styled "The County Case Fund of the State Mining Bureau and Museum," to provide neat and uniform cases, which will bear the names of the respective counties so contributing.

It is also most earnestly requested that immediate measures be taken by the respective Boards to solicit specimens, which may be sent by express, free, directed to the State Mining Bureau, with names of donors, which will appear on printed display cards in the respective county cases.

Many relics, fossils, etc., will no doubt be sent which cannot go in cases, and for these a county space will be assigned by the committee.

Believing that the main thoughts aimed at and brought out in this circular will afford an ample incentive to earnest and practical effort, and that opportunity will be furnished for one of the most important displays the State has ever made, we submit this circular, hoping that what it asks for and aims at will meet with your approbation and receive your hearty coöperation.

We are, gentlemen, yours very respectfully,

MELVILLE ATTWOOD,  
L. L. BULLOCK,  
W. M. BUNKER,  
WM. T. COLEMAN,  
JAMES V. COLEMAN,  
C. O'CONNOR,  
JACOB Z. DAVIS,  
JOHN DAGGETT,  
WARREN B. EWER,  
S. HEYDENFELDT, JR.,  
C. A. HOOPER,  
GEO. T. MARYE, JR.,  
W. H. MILLS,  
ALMARIN B. PAUL,  
I. M. SCOTT,  
J. R. SCUPHAM,  
CHAS. M. TYLER.

### Letter accompanying Circular No. 1:

#### PACIFIC COAST MINERAL EXPOSITION.

ROOMS OF THE CITIZENS' COMMITTEE, 212 SUTTER STREET,  
SAN FRANCISCO, April 21, 1883. }

*To the Clerk of the Board of Supervisors, — County, California:*

DEAR SIR: Inclosed please find circular letter in triplicate, addressed to your honorable Board of Supervisors. I believe it will be your pleasure to send the same to the gentlemen of the Board in their respective districts, if they are not at the county seat, retaining one for yourself that you may be able to advocate the purpose set forth. An early response is earnestly desired.

Very respectfully,

S. HEYDENFELDT, Jr.,  
Secretary of Committee.

A special committee was appointed to draft Circular No. 2, informing the public that an exposition would be held, and Circular No. 3, giving instructions how to pack and send specimens, both of which were accepted, ordered printed, and sent to the several county seats, and to every newspaper published in the State. A large number were reserved for distribution in the city.

[Circular No. 2.]

#### PACIFIC COAST MINING EXPOSITION.

ROOMS OF THE CITIZENS' COMMITTEE,  
212 SUTTER STREET, San Francisco. }

During the session of the Triennial Conclave of the Knights Templars, to be held in San Francisco during the month of August, 1883, it is variously estimated that from 15,000 to 50,000 strangers will visit this city.

In view of this unusual influx of visitors there has been inaugurated by the citizens of San Francisco a Pacific Coast Mineral Exposition, to be held in this city and kept open daily, for the free admission of the public, during the month of August.

The exhibits will be in two general classes, viz.: Donations to the State Museum, which will remain on permanent exhibition after the close of the exposition; and loan exhibits, which will be returned to the owners at the close of the exposition.

In order to make the exposition worthy of our State, all citizens are requested to take a personal interest therein, and forward, either directly to the State Mining Bureau, or through their own county committee, any specimens which may represent any of the resources of the State or are of interest otherwise.

It is desirable to exhibit specimens of all ores occurring in the State, such as gold, silver,



copper, lead, antimony, tin, nickel, quicksilver, iron, etc.; also clays suitable for brick, fire-clay, pottery, porcelain, etc.; useful and ornamental stones for building, paving, and statuary, lime, plaster, etc.; cements, natural and artificial, mineral oils, crude and manufactured; soda and borax, crude or manufactured; nitrates, chromic iron, rocks and minerals of all kinds, salt, coal, fossils, woods, native and cultivated, fibrous plants, native and cultivated; paper material, native and cultivated; tanning material, native and cultivated; sands suitable for glass-making, etc.; mineral soap, soapstone, Indian relics, and specimens of curious natural formations of any kind that may be interesting.

Information regarding packing, etc., may be found posted up in your Post Office, and copies of these directions may be had of the Postmaster, or of the regularly appointed committee of your county.

Specimens will be received from this date until August 1, 1883, for exhibition during the exposition.

The Citizens' Committee is as follows:

GEORGE T. MARYE, JR., Chairman,  
 IRVING M. SCOTT, Vice-Chairman,  
 S. HEYDENFELDT, JR., Secretary,  
 ALMARIN B. PAUL, Corresponding Secretary,  
 LLOYD TEVIS (Pres't Wells, Fargo & Co.), Treasurer,  
 MELVILLE ATTWOOD,  
 L. L. BULLOCK,  
 W. M. BUNKER,  
 WILLIAM T. COLEMAN,  
 JAMES V. COLEMAN,  
 C. O'CONNOR,  
 JACOB Z. DAVIS,  
 JOHN DAGGETT,  
 WARREN B. EWER,  
 C. A. HOOPER,  
 W. H. MILLS,  
 J. R. SCUPHAM,  
 CHARLES M. TYLER.

[Circular No. 3.]

#### PACIFIC COAST MINERAL EXPOSITION.

##### *Directions to Exhibitors.*

1. Specimens should not be less than two inches in diameter, excepting very rare or valuable minerals.
2. Wrap each specimen up carefully in paper, with a label inclosed, stating locality as exactly as possible—section, township, and range, and name of county—also the name of donor.
3. When two or more specimens are sent at the same time, observe Rule 2, and pack together tightly so as to avoid any rubbing of the specimens.
4. When a number of specimens are sent in one box, in addition to the regular label (Rule 2) have them numbered and a list of corresponding numbers made out and sent in the box.
5. Tack on the regular address card of the State Mining Bureau, or address "State Mining Bureau, 212 Sutter Street, San Francisco."
6. Use every precaution in sending fragile specimens; pack separately in small box so that they do not damage from defective packing.
7. Before sending unusually bulky or weighty specimens, correspond with the Secretary of the committee concerning same.
8. Advise the State Mining Bureau of every shipment, stating when and how the shipment was made.
9. Send all small packages of twenty pounds or less by Wells, Fargo & Co.'s Express, and charges will be attended to at this office.

April twenty-fourth a meeting was held for general consultation, at which it was decided that all matters of detail be left to the Executive Committee, who were instructed to proceed in arranging the business of the exposition, and to procure the necessary material and assistance for advancing the same. April twenty-sixth a meeting of the Executive Committee was held, and the following resolutions adopted unanimously:

WHEREAS, San Francisco will be visited by many thousand people in consequence of the holding of the Triennial Conclave of Knights Templars during the month of August of this year, and the committee deeming it advisable to have the mineral wealth of the Pacific Coast fully represented, and exhibited by the State Mining Bureau; therefore, be it

*Resolved*, That the Executive Committee appointed by the Chairman of the Citizens' Committee, Geo. T. Marye, Jr., solicit and collect subscriptions of money, and procure mineral specimens in addition to those now in the museum of the State Mining Bureau, for the purpose of having exhibited a representative collection of the minerals of this coast, to be made as full and complete as practicable; and to increase the scope of the Mining Bureau, and to aid it in disseminating useful information.

*Be it further resolved*, That all moneys collected by the Executive Committee, or by any member thereof, be deposited with *Mr. Lloyd Tevis*, Treasurer of this committee, to be expended and applied for the purposes aforesaid, and expressed by the said Executive Committee at its regular and special meetings, and that all specimens received shall be given to the State Mining Bureau, excepting such as may be loaned to the exposition.

*Be it further resolved*, That the said Executive Committee be and is hereby authorized and empowered to issue letters and circulars setting forth the importance of carrying out the objects contemplated in the foregoing resolutions.

*Be it further resolved*, That a copy of these resolutions be sent to the Supervisors of every county in the State, requesting their cooperation, and that the press of the State be urged to give publicity to the objects which the committee has in view.

#### THE HONDURAS EXHIBIT.

About the date of this report his Excellency Marco A. Soto, President of the Republic of Honduras, arrived in San Francisco with a large and valuable collection of the ores, minerals, fossils, woods, fibers, manufactures, etc., of his country, and a very interesting collection of antiquities from the ancient City of Copan. He applied to the Mining Bureau for the privilege of exhibiting his collections in the State Museum, which was granted. The exhibit, which was a very fine one, remained in the museum for a number of days. On removing the specimens many duplicates were presented to the State Museum by President Soto, constituting a fair representation of the entire Honduras exhibit, and including a full set of the woods of the country, which in itself is a very valuable donation. The collection of antiquities, filling two museum cases, was loaned to the museum for an indefinite period, and will remain on exhibition. It forms an attractive feature of the museum, supplementing as it does the State collection of antiquities.

Among the minerals shown by President Soto were some remarkably fine opals, for which Honduras is celebrated; a large exhibit of placer gold, and cakes of silver obtained from the cupellation of lead reduced from galena. Also some beautifully chased silverware, the manufacture of Hondurians, both ancient and modern.

The ruined City of Copan is in the department of Gracias, Honduras. The ruins lie in a dense forest, and cover an area extending for two miles on both sides of the Copan River, a branch of the Motagua, from which the city takes its name.

Among the wonderful ruins are the partly fallen walls of a great building 624 feet long, supposed to have been a temple. The inclosure is well paved with blocks of cut stone.

From the river to the temple there is a grand stairway of cut stone, and many monoliths of great size, covered with hieroglyphics in an unknown language, are found near by, many of them still standing. These monoliths, which are elaborately sculptured and very ornamental, are peculiar to Honduras, and their meaning and history are probably given in the unread inscriptions which await an unfound rosetta stone or other key to the deeply cut hieroglyphics. At the time of the Spanish conquest the conquerors found these ruins in their present condition, without a history and with scarcely a tradition.

Among the numerous specimens loaned by President Soto to the State Museum are grotesque ornaments in baked clay, ornamented vessels of the same material, vessels cut in stone, fragments of the characteristic monoliths above mentioned, and ornaments and designs showing both taste and skill on the part of the ancient sculptors. A very remarkable and beautiful corn mill of diorite is shown with roller of stone, upon which the modern rolling pin is no improvement. On the gracefully curved face of the mill, cakes or flat sheets of bread were prepared. The character of this beautiful utensil is such, and the amount of labor expended in its construction so great, that none but a person of wealth or high position could have owned it.

Another remarkable carving is that of a sphinx, which seems to prove that the ancient people were in communication, direct or indirect, with the Egyptians, and it seems as likely that the latter derived their idea of that fabulous monster from the citizens of Copan, as the reverse.

#### VISITORS.

Since the last report the number of visitors has notably increased, the museum becoming more widely known. From the commencement up to June first, 8,172 names have been entered in the register. But this by no means represents the number of visitors, for an unaccountable reluctance to register has been noticed, and those who have previously visited the museum frequently decline to enter their names again. There is no way of keeping a record of the visitors, while no regular museum attendant is employed. It is safe to estimate five visitors for each name registered. Many persons daily visit the offices of the Mining Bureau for information and on business who do not enter the museum.

#### DEATH OF JOSEPH WASSON.

Since the publication of the last report the Honorable Joseph Wasson, to whom is due the founding of the State Mining Bureau, died in Mexico. The date of his death was April 18, 1883. He was appointed United States Consul for the port of San Blas, and his friends thought the change of climate would restore his failing health. This hope, unfortunately, proved groundless. However great the State Mining Bureau may become in the future, the name of Joseph Wasson will always be associated with its commencement.

Mr. P. L. Peters, a well known artist of San Francisco, offered to paint, gratuitously, a portrait of Mr. Wasson from a photograph taken before his death. He has produced an admirable likeness, which has been hung in the library of the State Mining Bureau as a part of the history of the institution.

This incident suggested the idea of obtaining and preserving portraits of all those connected with the geological surveys of the State. To this end a small photograph of Dr. J. B. Trask, first State Geologist of California, was obtained from his wife and enlarged and retouched by C. E. Watkins, of San Francisco, which is now also framed and hung in the library. A letter was written to Professor J. D. Whitney, former State Geologist, asking for his photograph, and he has promised to send it, but up to the present time it has not been received. These portraits will be more prized in the future than now.

## ANTICIPATED REMOVAL.

Notice has been given to the State Mineralogist that the building now occupied by the State Mining Bureau will soon be remodeled, and that it will be necessary for the museum and offices to be removed during that time. No date has been set for the work to commence, but removal is only a question of time. The work will probably be commenced immediately after the Winter rains.

To move the museum implies the packing in boxes of all the museum material, and replacing it again in the new rooms. To those who have had no experience, the magnitude of this work cannot be realized; nor can it be done without loss, for some of the specimens are so fragile that they may become broken, notwithstanding the greatest care. The Mining Bureau has before been compelled to remove at short notice, and for the same reason. It will be very difficult to find rooms suitable for the purpose, and at the present this seems almost impossible. Unless there is some provision made for a permanent building, there seems to be no alternative but to pack the specimens in boxes and store them for an indefinite period. But such a course would be a serious blow to the institution, and one from which it would not soon recover.

## DANGER OF FIRE.

In my second report I alluded to the danger of fire, and the great loss the destruction of the museum would be to the State. The importance of this subject becomes greater with the increase of the collections. It is a question whether it would not be better to sacrifice accessibility to safety, and to remove the museum to the Park or other locality with less risk of fire. To test the practicability of such a move, I made application to the Park Commissioners, asking them if a building could be furnished, but as yet have received no reply.

The museum should as soon as possible be placed in a suitable building, which should be absolutely fireproof.

## STATE MAP.

In a recent report, the State Engineer called attention to the large map of California in his office. This is a very valuable work, and one that is not fully appreciated by the people.

It is proposed to issue the map in sections, which should furnish the groundwork for all future maps of the State. Each County Surveyor should be furnished with sheets, upon which he could fill in the details of his county surveys. The State Mineralogist should have sheets, upon which the results of his study of the geology of the State could be entered from time to time, and the locality of all known minerals marked.

The want of such a map is daily felt in this office. The United States map of California, used by the State Mineralogist, was sent to the State Engineer, who has marked upon it lines showing the sheet sections of his great map.

It is to be hoped that early action will be taken to furnish sectional sheets to all those working in the interest of the State.



## ECONOMIC CONSIDERATIONS.

It is beyond question that mining and metallurgy as practiced in California are wasteful and extravagant. The amount of gold lost in milling and hydraulic mining is much greater than is generally admitted. As an example of the latter I give a statement recently made to me:

May 26, 1883, Mr. C. H. Hankins, of Nevada County, called at the State Mining Bureau and stated that he had, during a period extending from 1869 to date, taken \$125,000, in gold, wholly from tailings rejected by the Bird's-eye Creek Hydraulic Mining Company, at You Bet, Nevada County, in this State. After saving all he could, his tailings still contained gold, which would pay to work, but which were no longer on his ground. He employs the same water used by the hydraulic company, and in the same kind of sluices.

For five or six years the gross yield per annum has been \$16,000. He has never seen *rusty gold*, and knows nothing of the subject. The hydraulic company uses 1,500 inches of water.

Mr. Hankins thinks the large quantity of gold in the tailings could be recovered by ground sluicing, even if hydraulic mining should be stopped. His plan is to commence at the lower end of the cañon, which is a mile or more long, and to sluice out the tailings, now seventy-five feet deep. The gold is very fine.

Professor Edison was the first, I believe, to call public attention to the presence of gold in tailings from hydraulic mines, in a condition invisible to the eye, and in considerable quantities. In June or July, 1879, he sent letters to many hydraulic mines in California, and to individuals, asking for information, and for samples of platinum, which he found indispensable in his electric light inventions. This led to his receiving many samples, in some of which he found large proportions of gold, as stated. He then invented an apparatus for separating the magnetic particles, figured in the Mining and Scientific Press of June 15, 1881, and in the Popular Science Monthly of a recent date. At the time, I thought he was mistaken as to the quantity of gold, or had based his opinion on an accidental specimen of unusual richness. But recent experiments made by myself, and others by Mr. A. B. Paul and Melville Attwood, have fully sustained him. It is difficult to understand how hydraulic miners have generally overlooked this great loss.

It has long been known that placer miners did not save all the gold, and instances are numerous in which they have washed the same ground several times, realizing a crop of gold from each washing nearly as great as the first. But it has been claimed that with improved appliances, hydraulic miners saved nearly all of the precious metal. Few Superintendents are willing to admit a loss greater than fifteen per cent. Mr. Hankins' success, and the discovery by Professor Edison, show the fallacy of this estimate.

The more that hydraulic sands are studied the more interesting the subject becomes. Realizing this, I have collected sands from many parts of the State for future study and reference. The question of slickens and mining debris as antagonistic to agriculture, is one of great importance to the State. It has been thought best to study the soils as well, to learn any lesson they may teach as to the natural disintegration of the rocks, which seems to have been generally over-

looked in the more important study of slickens and debris, produced by artificial means. I have prepared, also, several sets of microscopic slides, as shown in the following extract from the museum catalogue. One set of each has been sent to the following institutions:

The Geological Society of England.  
 The Geological Society of France.  
 The Royal Microscopical Society of London.  
 The Microscopical Society of San Francisco.  
 And one set retained in the State Museum.

#### MICROSCOPE SLIDES,

*Showing the condition of Alluvial Gold as collected in Hydraulic, Placer, and Drift Mining in California, with associate minerals found in "cleaning up" the sluices, as described in the Reports of the State Mineralogist of California. (Presented by the California State Mining Bureau.)*

4556.—Microscope Slide. Crystallized Gold, White Bull mine, Linn County, Oregon. See Report State Mineralogist for 1882, folio 144.

4557.—Microscope Slide. Gold Crystals after stibnite. (?) Lake mine, Napa County, California. Several pans of dirt were taken from the gulch, washed down in a miner's pan to a small quantity, a portion of mercury added, the mercury separated without rubbing, and boiled in nitric acid; these pseudomorphic (?) crystals remained. An attempt was made to produce similar crystals by treating precipitated gold in the same manner, but without success.

4558.—Microscope Slide. Gold from a quartz mine, Beverage, Inyo County, California. Some of the gold is rolled into cylinders under the muller while being crushed.

4559.—Microscope Slide. Placer Gold from upper San Joaquin River, Fresno County, California. This gold is fine and free from coating, except to a slight degree on some of the pieces. It shows a tendency to crystallize.

4560.—Microscope Slide. Placer Gold, San Luis Obispo County, California. Very pure and free from coating.

4561.—Microscope Slide. Placer Gold from shores of Mono Lake, Mono County, California. This gold is remarkably pure and free from coating. It amalgamates perfectly and immediately on being brought in contact with mercury.

4562.—Microscope Slide. Placer Gold, Chile Gulch, Calaveras County, California. This gold is in a cryptocrystalline state not easy to account for. Many of the grains inclose quartz, which would seem to indicate that it has its origin in some quartz vein in the immediate vicinity. It differs from ordinary placer gold, and may have been collected by mercury and overheated in the retort. The Mining Bureau has no history of this specimen more than is shown in the label.

4563.—Microscope Slide. Electrum, Bodie, Mono County, California. See First Annual Report of State Mineralogist, folio 25.

4564.—Microscope Slide. Gold and Platinum, beach at Coos Bay, Coos County, Oregon. See Report of State Mineralogist for 1882, folio 252.

4565.—Microscope Slide. Typical specimen of Coated or "Rusty" Gold, Red Hill Hydraulic Mine, Butte County, California. All attempts to collect such gold by amalgamation results in failure; for this reason a large proportion of the placer gold, and especially that from the ancient river beds, is lost to the world. The loss is so great, and the matter so serious, that miners, inventors, and scientific men should devise some plan by which such gold may be saved. Attention is called to this subject in Report of State Mineralogist for 1882, folio 117.

4566.—Microscope Slide. Rusty or Coated Gold, from a large deposit of tailings below Oroville, Butte County, California. Described in First Annual Report of State Mineralogist, folio 39. It may be seen that the particles of gold are not to the same extent coated, but that all are more or less so.

4567.—Microscope Slide. Placer Gold from the Bonanza Hydraulic Mine, Gold Run, Placer County, California, collected in crevicing. The particles are considerably coated. Crevicing has been described in Report of State Mineralogist for 1882, folio 113.

4568.—Microscope Slide. Placer Gold, coated with silica by pressure and friction, from the Blue Lead bedrock, below the gravel, Chalk Bluffs, Nevada County, California.

4569.—Microscope Slide. Placer Gold with pyrite and magnetite, Nevada County, California. The gold is, to a considerable extent, coated.

4570.—Microscope Slide. Hydraulic Gold, amalgamated and boiled in nitric acid, by which the mercury was dissolved. The product is beautifully crystallized. The gold used was amorphous.

4571.—Microscope Slide. Gold precipitated from solution of sesquichloride by solution of protochloride of iron.

4572.—Microscope Slide. Precipitated Gold (see No. 4571), amalgamated and boiled in nitric acid. It is cryptocrystalline, but in no way resembles No. 4570, or No. 4557, which might be expected.

4573.—Microscope Slide. Gold (portion E, Report of State Mineralogist for 1882, folio 114) from Spring Valley Hydraulic Mine, Butte County, California. This gold was in the form of amalgam, from which the mercury was volatilized by heating to redness in a porcelain capsule.

4574.—Microscope Slide. Platinum with indosmine, Mormon Island, Sacramento County, California.

4575.—Microscope Slide. Platinum and iridium. Concentrations from Spring Valley Hydraulic Mine, Cherokee, Butte County, California. See No. 4224, and Report of State Mineralogist for 1882, folio 252.

4576.—Microscope Slide. Concentrations from placer washings, Chiquita Joaquin, Fresno County, California. Containing zircons with gold; curious as showing gold in two conditions, as pure gold, or nearly so, and as electrum, a natural alloy of gold and silver. See No. 4563.

4577.—Microscope Slide. Gem Sand (so called), Lower Gold Bluffs, Humboldt County, California. Containing gold, platinum, magnetite, chromite, quartz, zircons, and red crystals. It is the result of natural concentration by the action of the waves on the ocean beach.

4578.—Microscope Slide. Concentration from Spring Valley Hydraulic Mine, Cherokee Flat, Butte County, California. (Portion D.) Zircons picked out by hand. See Report of State Mineralogist of 1882, folio 114.

4579.—Microscope Slide. Zircon Sands, Amador County, California. Concentrated in placer mining.

4580.—Microscope Slide. Dune Sands, San Francisco, California. Described in Report of State Mineralogist of 1882, folio 196. All, or nearly all, of the grains are rounded. In this deposit, which is quite extensive near the City of San Francisco, there are beds of iron sands in varying stages of decomposition, showing how some sandstones are mottled and become shaded in process of induration.

4581.—Microscope Slide. Fine Sand from the Colorado Desert, San Diego County, California. The grains are rounded by the action of both water and wind. See Report of State Mineralogist for 1882, folio 236.

4582.—Microscope Slide. Fine Sand from Spring Valley Hydraulic Mine, Cherokee, Butte County, California. All the grains are angular.

4583.—Microscope Slide. Fine Quartz Sand from the Polar Star Hydraulic Mine, Dutch Flat, Placer County, California. (Portion H, after boiling in nitric acid.) See Report of State Mineralogist for 1882, folio 101. All the grains are sharp and angular.

4584.—Microscope Slide. Tryonia clathrata. Tertiary fossils mentioned in Report of State Mineralogist of 1882, folio 229. Colorado Desert, San Diego County, California.

4585.—Microscope Slide. Placer gold with globular pyrite in the form of sand. Last Chance Mining District, Placer County, California. This gold is but slightly coated. The small concavities are in some cases coated with silica, and some grains show the pyrite attached. The gold is remarkably fine, probably the most so of any in the State, being 996 fine. The pyritic sand is very interesting when examined microscopically. This association is rather rare. The exact locality is section 34, township 15 north, range 12 east, Mount Diablo meridian.

Mr. Attwood has made a special study of No. 4557 of the above catalogue, from the result of which he thinks it to be amalgam, and not a pseudomorph, as at first supposed.

To obtain soils for microscopic examination, circulars were sent to the following Post Offices, from nearly all of which samples were received. This collection of soils is highly interesting, and there is sufficient quantity of each to admit of a chemical analysis when a suitable laboratory is provided:

POST OFFICES TO WHICH CIRCULARS WERE SENT ASKING FOR SAMPLES OF SOIL.

- |                    |                  |                   |
|--------------------|------------------|-------------------|
| 1. Alma,           | 17. Calpella,    | 33. Davenport,    |
| 2. Altoona,        | 18. Capell,      | 34. Douglas City, |
| 3. Allendale,      | 19. Carpenteria, | 35. Drytown,      |
| 4. Bakersfield,    | 20. Cedarville,  | 36. Dunnigan,     |
| 5. Ballena,        | 21. Cherokee,    | 37. Eureka,       |
| 6. Bath,           | 22. Cholame,     | 38. Elder Creek,  |
| 7. Bear Valley,    | 23. Cisco,       | 39. Elk Creek,    |
| 8. Bellota,        | 24. Citrus,      | 40. Elliott,      |
| 9. Benton,         | 25. Clarksburgh, | 41. Emmett,       |
| 10. Bieber,        | 26. Clayton,     | 42. Etna Mills,   |
| 11. Bolinas,       | 27. Clear Creek, | 43. Fairford,     |
| 12. Bullards Bar,  | 28. Cloverdale,  | 44. Farmersville, |
| 13. Burgettsville, | 29. Coloma,      | 45. Felton,       |
| 14. Crescent City, | 30. Columbia,    | 46. Forest Home,  |
| 15. Caliente,      | 31. Coyote,      | 47. French Camp,  |
| 16. Calistoga,     | 32. Downieville, | 48. Geyserville,  |

49. Glencoe,	60. Milton,	71. Requa,
50. Grayson,	61. Meadow Valley,	72. Ripon,
51. Gualala,	62. Minersville,	73. Rock,
52. Hueneme,	63. Mohawk,	74. Soquel,
53. Judsonville,	64. Mono,	75. Susanville,
54. Kernville,	65. Monticello,	76. Soledad,
55. Kingston,	66. Moons Ranch,	77. San Luis Obispo,
56. Lakeport,	67. Newberry Park,	78. Santa Barbara,
57. Los Baños,	68. Princeton,	79. San Bernardino,
58. Linden,	69. Poway,	80. Saticoy,
59. Markleeville,	70. Quincy,	81. Tehama.

A serious loss of gold attends the milling of quartz, even in the best mills of the State, but I am not prepared to state to what extent. The principal loss occurs in the concentration, roasting, and chlorination of the sulphurets containing gold, which are not decomposed in the process of milling, but which require special treatment as above. This loss arises from several causes: First—From defect in the concentration, which in many cases is unskillfully done. Second—Roasting, in which a serious loss results from the volatility of the gold, as proved by the specimen in the museum of the State University, and mentioned on folio 152 of the Second Report of the State Mineralogist. The sulphur, too, is wasted—a very valuable product, which should be saved, and made into sulphuric acid, to be used in the metallurgy of the very ores from which it is extracted. Third—In the operation of chlorination the loss of gold is known to be considerable. The roasted sulphurets, after treatment to extract the gold, are thrown aside as worthless, when they contain iron in the condition best suited for its extraction by sulphuric acid, to obtain green vitriol, or other salts of iron, or to be smelted as other iron ores are smelted, or washed with water, whereby a valuable pigment may be produced, almost equal to the best Venetian red. At the iron furnaces at Clipper Gap, Placer County, great quantities of wood are burned in kilns to produce the charcoal required to smelt the iron; all the methylic alcohol and pyroligneous acid are allowed to go to waste. The loss of coal slack at the coal mines is very great. In other countries this material is used as a manure, or is made into blocks by the addition of coal tar or other suitable cement, and burned.

Large sums of money are expended for steam engines and fuel, where ample water power is running to waste.

Great quantities of low grade ores of lead, copper, tin, antimony, zinc, etc., are allowed to lie unworked, because they will not pay by the extravagant methods in general use; and yet low grade ores must take the place of those of higher grades, which are more difficult to find and less reliable, but which are now considered the only ores worth working.

In the deserts of California and Arizona, where water is very difficult to obtain, even for drinking, dry washing becomes a matter of the greatest importance. The following description is in reply to a letter of inquiry sent by the State Mineralogist:

You wish a description of our method of dry washing. We first find a ravine supposed to contain gold, in which we sink a hole to the bedrock; take a sample of twenty pounds of gravel from the pay streak and pan it out in a batea without water. If the result is satisfactory, we then proceed to strip the gravel from the top to within six inches of the bedrock.

After having stripped a large surface, we then carefully mine the pay streak, and sweep the bedrock clean, and screen the entire lot through a wire screen of three-eighths-inch mesh, which assists in drying and pulverizing the material. We then feed the mass into the hopper of the Wangaman gold dry washer, and remove the concentrations every fifteen minutes. At the close of the day we have three hundred to four hundred pounds of the concentrations, which we



carefully run through the machine twice, and the result of the day's work is contained in about twenty pounds of concentrations, which consist principally of black sand, iron, shot, carbonate of bismuth, and gold.

The gold is separated from the other concentrations by the aid of water and quicksilver in a miner's pan.

WILLIAM K. SIME,  
Phoenix, Arizona.

In Nevada advantage has lately been taken of the abundant dry sand to produce a steady power, which cannot be obtained by wind. The sand is elevated to a tank of sufficient height by an elevator of cups attached to a leather belt, set in motion by a windmill of sufficient power. The sand is run through a spout to the buckets of an overshot wheel of considerable diameter, which drives the concentrators or other machinery. The sand is returned to a vat below the elevator, and is used again and again. This apparatus is as yet an experiment, but there seems to be no reason why it should not be used (perhaps in some modified form) for concentration, where wind and dry sand are plenty, and wood and water scarce.

Too much cannot be said as to the importance of minerals other than those of gold and silver, and properly designated as *economic minerals*, which exist in California in the greatest abundance. It is a question if they are second in importance even to gold itself.

Coal, iron, salt, clay, and sulphuric acid are the foundation of manufactures. Clay, iron, and salt are known to exist in large quantities in the State. Coals, suitable for most purposes, are also abundant, and coal of a superior quality has been found at several Pacific Coast localities, which can be supplied in any quantity when wanted. Sulphur and pyrites are the foundation of sulphuric acid, which has been called *the king of acids*, for by its use all others are separated from their compounds. It is the foundation of all the great chemical manufactures. Pyrites is very abundant in the State. Sulphur is also found at several localities, but a great deal of this mineral has been imported from Sicily and Japan. Great quantities of pyrites containing a small portion of copper are imported into England and burned in extensive lead-lined chambers, for the sulphuric acid they will produce; after which they are treated for copper. What remains is largely oxide of iron, which is partly reduced to metal, and partly used in various manufactures. The amount of domestic pyrites raised in the United Kingdom in a single year has been as much as 65,916 tons, the value of which was £39,470 sterling.

The roasting of sulphurets containing gold, in the chlorination process, as practiced in California, is wasteful in the extreme; as before mentioned, not only is a notable portion of the gold lost, but all the sulphur, arsenic, and other valuable substances allowed to go to waste. These by-products should be utilized and included in the profits.

The first question asked at the Paris Exposition of 1878, when the California minerals were displayed, was, "Where are your fertilizers?" and next, "Where are your coals?"

It will be well to consider the import of these inquiries. If we do not return some equivalent to the soil, the crops will gradually become less bountiful, until a period will be reached when they will not pay to harvest. If we do not turn our attention to manufactures we cannot expect to reach a condition of great prosperity.

The question of fertilizers is one of the greatest importance to the world at large, and enormous capital is invested in their production and transportation. It is worthy of note that bone dust is somewhat largely produced in California, and is mostly, if not wholly, exported. Gypsum and marl are to be found in the State, and will eventually be utilized. Because native phosphates have not been discovered, it does not follow that they do not exist. The amount of Peruvian guano imported into England from 1844 to 1873 is estimated to be 5,500,000 tons. Mineral manures are extensively manufactured in Great Britain. In the year 1873 the yield of phosphatic nodules, or coprolites, at one locality in England, was 32,000 tons.

The amount of common sand consumed in large cities is almost incredible. The capital invested in the sand trade of New York City is estimated at two million dollars. Four thousand five hundred tons of sand, on an average, are sent to the great city daily, in boats, from the beaches of New Jersey. So it is with other minerals generally considered of little or no value, yet they are indispensable, and play an important part in the arts which confer comfort and convenience on mankind.

The following list of the most important economic minerals has been prepared to show how varied and numerous they are. If those found in California cannot immediately be made available, it does not follow that they are the less valuable. It is too often the case that those finding deposits of minerals regard them only as a source of immediate wealth, and if the mine or deposit cannot be at once sold it is abandoned as worthless. But while the failure to do this is the cause of disappointment to the individual, the information so gained is of great importance to the State, and will be taken advantage of when a demand is created by the increase of population and manufactures.

#### LIST OF THE MOST IMPORTANT ECONOMIC MINERALS.

*Those in CAPITALS have been found in the State.*

- |           |                      |                  |
|-----------|----------------------|------------------|
| 1. ALUM,  | 3. ANHYDRITE,        | 6. BORACIC ACID, |
| 2. Amber, | 4. ASBESTUS,         | 7. BORAX.        |
|           | 5. Bath Brick Stone, |                  |

#### *Building Materials.*

- |  |                             |                    |
|--|-----------------------------|--------------------|
| 8. AGALMATOLITE, or figure stone,                            | 16. DIATOMACEOUS EARTH,     | 27. MARBLES,       |
| 9. ALABASTER,  | 17. FIRE STONE,             | 28. Oolite,        |
| 10. ASPHALTUM,   | 18. FREESTONE,              | 29. Puzzolana,     |
| 11. BROKEN STONE, for rubble, street pavements, and macadam; | 19. GNEISS,                 | 30. SAND,          |
| 12. BASALT,  | 20. GRANITE,                | 31. SANDSTONE,     |
| 13. BITUMEN,   | 21. GREENSTONE,             | 32. SCHIST,        |
| 14. CEMENT STONE,  | 22. GYPSUM,                 | 33. SERPENTINE,    |
| 15. DIORITE,   | 23. HYDRAULIC LIMESTONE,    | 34. SLATE,         |
|  | 24. INDURATED VOLCANIC ASH, | 35. TILE STONES,   |
|  | 25. LAVA,                   | 36. Verde Antique. |
|  | 26. LIMESTONES,             |                    |
| 37. BURR MILL STONE,   | 39. Carbonate of Strontia,  | 41. Chalk,         |
| 38. Carbonate of Baryta,                                     | 40. Carnallite,             | 42. CHROMIC IRON.  |

#### *Clays.*

- |                 |                     |                       |
|-----------------|---------------------|-----------------------|
| 43. BLUE CLAY,  | 45. FIRE CLAY,      | 48. Pipe Clay,        |
| 44. BRICK CLAY, | 46. Fuller's Earth, | 49. TERRA COTTA CLAY. |
|                 | 47. KAOLIN,         |                       |
| 50. Cryolite,   | 51. Emery,          | 53. FOSSIL GUMS.      |
|                 | 52. FELDSPAR,       |                       |

*Fuels.*

- |                       |              |                |
|-----------------------|--------------|----------------|
| 54. BITUMINOUS SHALE, | 56. LIGNITE, | 58. PETROLEUM. |
| 55. COAL,             | 57. PEAT,    |                |

*Gems and Semi-precious Stones.*

- |                  |                   |                         |
|------------------|-------------------|-------------------------|
| 59. Ambrite,     | 66. Emerald,      | 73. OPALS,              |
| 60. AGATE,       | 67. JASPER,       | 74. Ruby,               |
| 61. BLOOD STONE, | 68. JET,          | 75. Sapphire,           |
| 62. CAT'S EYE,   | 69. Lapis Lazuli, | 76. SILICIFIED WOOD,    |
| 63. Cannel Coal, | 70. MALACHITE,    | 77. Topaz,              |
| 64. CHALCEDONY,  | 71. OBSIDIAN,     | 78. Turquoise.          |
| 65. DIAMOND,     | 72. ONYX,         |                         |
| 79. GLAUBERITE,  | 82. ICELAND SPAR, | 85. LITHOGRAPHIC STONE, |
| 80. GRAPHITE,    | 83. Kainite,      | 86. MINERAL WATERS.     |
| 81. Hone Stone,  | 84. Kieserite,    |                         |

*Mineral Manures.*

- |                          |                      |                        |
|--------------------------|----------------------|------------------------|
| 87. COAL SLACK, OR DUST, | 89. GUANO,           | 92. OCHRE,             |
| 88. Greensand,           | 90. GYPSUM,          | 93. Phosphate of Lime. |
|                          | 91. NITRATE OF SODA, |                        |

*Ores and Minerals Containing—*

- |                    |                          |                            |
|--------------------|--------------------------|----------------------------|
| 94. ANTIMONY,      | 103. Iridium,            | 112. Potash,               |
| 95. ARSENIC,       | 104. LEAD,               | 113. SODA,                 |
| 96. BISMUTH,       | 105. LITHIUM,            | 114. TELLURIUM,            |
| 97. Bromine,       | 106. MANGANESE,          | 115. TIN,                  |
| 98. COBALT,        | 107. MERCURY,            | 116. TUNGSTEN,             |
| 99. COPPER,        | 108. MOLYBDENUM,         | 117. Uranium,              |
| 100. CHROMIUM,     | 109. NICKEL,             | 118. VANADIUM,             |
| 101. IODINE,       | 110. PALLADIUM,          | 119. ZINC.                 |
| 102. IRON,         | 111. PLATINUM,           |                            |
| 120. Polyhalite,   | 126. Rotten Stone,       | 132. SULPHATE OF IRON,     |
| 121. PUMICE STONE, | 127. Sal Ammoniac,       | 133. Sulphate of Potash,   |
| 122. PYRITES,      | 128. SALT,               | 134. Sulphate of Strontia, |
| 123. QUARTZ,       | 129. SOILS AND SUBSOILS, | 135. SULPHUR,              |
| 124. RED CHALK,    | 130. SULPHATE OF BARYTA, | 136. THERANDITE,           |
| 125. Rag Stones,   | 131. SULPHATE OF COPPER, | 137. Whetstones.           |

It is the province of the State Mining Bureau to seek locations of all minerals having an economic value, to learn their quality and extent, and to place specimens in the museum for study and reference. To afford an opportunity to do this to the best advantage, the State Museum should be separated from the office of State Mineralogist, and be placed in charge of a Board of Directors or Trustees. The State Mineralogist should be ready and free to start at a few hours notice to any part of the State, to investigate any new or interesting discovery, and should make himself familiar with the condition of mines and mining. He should know by personal observation the localities of all the useful minerals in the State, and should spend most of his time in the field, collecting specimens and information; the first to enrich the museum, and the latter to be published in the annual reports.

# CALIFORNIA STATE MINING BUREAU.

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Part 2. Third Annual Report of the State Mineralogist.

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## REPORT ON THE BORAX DEPOSITS OF CALIFORNIA AND NEVADA,

GIVING THE PRODUCTION, CONSUMPTION, USES, HISTORY, CHEMISTRY, AND MINERALOGY OF  
BORACIC ACID AND ITS COMPOUNDS, AND OTHER GENERAL INFORMATION, WITH  
A MAP SHOWING THE PRINCIPAL LOCALITIES IN THE TWO STATES.

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By HENRY G. HANKS, STATE MINERALOGIST.



SACRAMENTO:  
STATE OFFICE, . . . . . JAMES J. AYERS, SUPT. STATE PRINTING.  
1883.





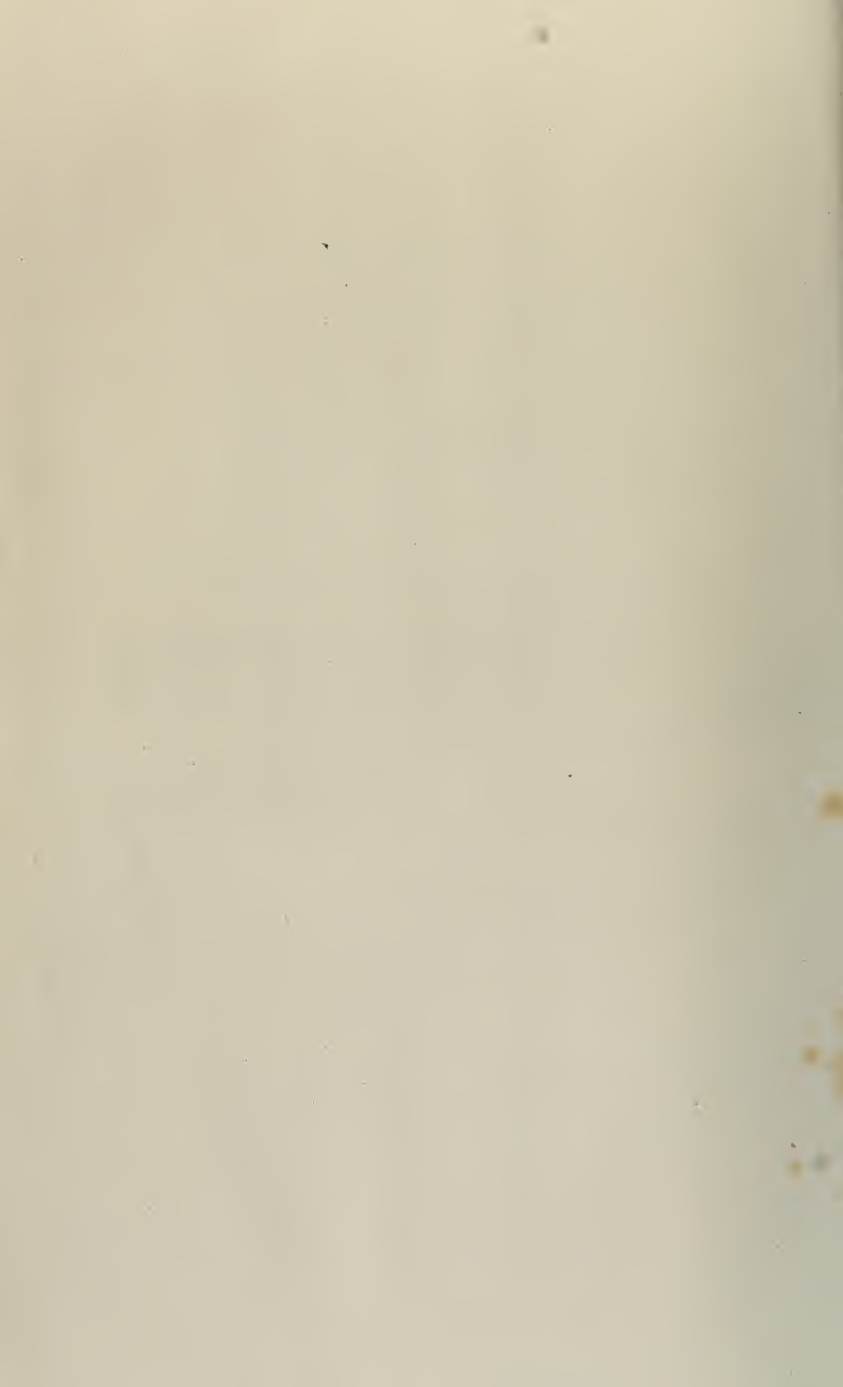
*To his Excellency* GEORGE STONEMAN, *Governor of California:*

SIR: I have the honor herewith to submit to you part second of the third annual report of the State Mineralogist of California, in compliance with Section 3 of an Act entitled "An Act to provide for the establishment and maintenance of a Mining Bureau," approved April 16, 1880.

I have the honor to be, very respectfully,

HENRY G. HANKS,  
State Mineralogist.

SAN FRANCISCO, June 1, 1883.



## INTRODUCTION.

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In this report I have endeavored, by compilation from every source at my command, joined to the results of personal observation and no inconsiderable original laboratory work, to render it so far a monograph as to afford the student, prospector, or dealer in borax, all information necessary to a general understanding of the subject.

The work is not intended to be scientific, but practical, and is specially prepared for the use of Californians interested in the production of borax, and for the public generally.

The work has been done during such time as could be spared from the more pressing demands of the Mining Bureau ; for this reason it is hoped that errors and omissions will be excused.

HENRY G. HANKS.

SAN FRANCISCO, June 1, 1883.



General View of the Boracic Acid Lagoons of Larderello, Province of Pisa, Italy. Copied from *Guida alle Acque Minerali D'Italia*, Guglielmo Jervis, Torino, 1868.

## BORAX.

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BIBORATE OF SODA, ACID METABORATE OF SODIUM (ENGLISH), BORATE DE SOUDE (FRENCH), BORAR, BORSAURE NATRON (GERMAN), BORRACE (ITALIAN), BOORAK OR BAURACH (ARABIC), SODÆ BIBORAS, PLINIAS CHRYSOCOLLA (LATIN), POUNXA, SWAGA, ZALA, TINCAL, TINKAL.

The word BORAX is of Arabic origin, and, as far as we know, appears first in the writings of Geber, an Arabian alchemist who lived in about the seventh century. The word "gibberish," anciently written *geberish*, was applied to his writings, which were filled with indefinite allusions. According to Professor Royle, the name *tincal* is derived from "*tincana*," the Sanscrit for borax.

The early history of borax is vague and uncertain. The statement by some writers, that the substance was known to the ancients, lacks confirmation. There is but little reason to believe that *chrysocolla*, literally, *gold glue*, was borax. Pliny's description shows it to have been of entirely a different nature. The name *chrysocolla* was given to borax by Agricola (*de re metallica*) because it was used in soldering gold. Agricola was a celebrated metallurgist who lived in the first part of the sixteenth century. One author (Parke's Chemical Essays, London, 1830) quotes from the writings (*Vita Caligulæ*) of Suetonius, who lived in the first century, that "the circus in his time was covered with vermillion and borax." The first borax known in Europe came from the East.

In 1732, Stephen Francis Geoffroy, a celebrated chemist, made the first analysis of borax, and was the first to notice the green flame imparted to burning alcohol by free boracic acid.

In 1748, Baron announced the discovery that borax was sedative salt and soda.

In 1772, the first authentic accounts were received in Europe as to the borax lakes of Thibet. According to Turner, "these lakes lie a few days' journey from Tezhoo Lomboo. The borax is found in masses in the mud at the bottom, beneath the stagnant water, with salt and alkali. Blanc and Pater Rovato say that these lakes lie among the mountains. The most noted (called *Neebal*) is located in the Canton of Sumbul. The water is conveyed in sluices, in which salt crystallizes. The liquor containing the borax is conducted to evaporating basins, in which the borax crystallizes out. It is impure, and has the form of six-sided crystals, sometimes colorless, at others, yellowish or green; always covered with an earthy incrustation, fatty to the touch, and with a soapy smell." Another account informs us that "the borax is dug from the margin of the lake. The crystals removed are replaced by others after the lapse of a certain time."

The following description of crude borax, as received in Europe at the time, is from the Elements of Mineralogy, Richard Kirwan; London, 1784:



Borax comes to Europe from the East Indies in a very impure state in the form of flat hexagonal, irregular crystals of a dull white or greenish color, greasy to the touch; or in small crystals, as it were, cemented together by a rancid, yellowish, oily substance, intermixed with marl, gravel, and other impurities. In this state it is called *brute borax*, *crysocolia*, or *tincal*. It is purified by solution, filtration, and crystallization, and the crystals thus obtained are calcined to free them from greasiness, and then dissolved, filtered, and crystallized a second time. Sometimes more mineral alkali is added, as it is said that tincal contains an excess of sedative salt. It has long been thought that borax was a factitious substance, but it is now beyond all doubt that it is a natural production, since M. Grill Abrahamson sent some to Sweden in the year 1772, in a crystalline form, as dug out of the earth in the kingdom of Thibet, where it is called *pounxa my poun* and *houi poun*. As borax is purified also in the East Indies, Mr. Engstrom suspects that tincal is only the residuum of the mother liquor of the borax evaporated to dryness, and that the greasiness arises from its being mixed with buttermilk to prevent its efflorescence. It is said to have been found in Saxony in coal pits.

Early writers knew but little about borax, as will be seen from the following quotations from old works on chemistry and mineralogy:

#### HISTORY OF BORAX.

[From the Chemical Works of Caspar Neuman, London, 1773.]

It is commonly said that borax is prepared in the eastern countries from a green saline liquor which runs from certain hills and is received in pits lined with clay, and suffered to evaporate by the sun's heat; that a bluish mud which the liquor brings along with it is frequently stirred up, and a bituminous matter which floats on the surface taken off; that when the whole is reduced to a thick consistence some melted fat is mixed, the matter covered up with dry vegetable substances and then a thin coat of clay, and that when the salt is crystallized it is separated from the earth by a sieve.

In some countries is found a considerable quantity of a native mineral ancalkine salt on the surface of the earth, sometimes tolerably pure, more commonly blended with heterogenous matters of various colors—the "*nitrum*" or "*natron*" of the ancients, the "*baurach*" of the Arabians—this alkali appears to be the same with the basis of this salt, and with the lixivial salt of kali or kelp, and some other maritime plants. It differs from the common vegetable alkalies in being milder and less acrid in taste, assuming a crystalline appearance, not deliquescent in the air, or very slowly, forming with the marine acid a perfect sea salt, with the nitrous, quadrangular nitre, and with the vitriolic, sal mirabile.

Mr. Pott received from Tranquebar, whence the greatest quantities of borax are made, a sand under the name of "*ore of borax*," with an account that certain acrid vegetable matters were added in the preparation of borax; the ore yielded on elixation only the mineral alkali, with a little sea salt.

The mineral alkali appears from experiment to be a principal ingredient in borax. On treating borax with acids about one fourth of its weight of a peculiar saline substance called "sedative salt," is separated, and the residuum proves a combination of the alkali with the acid employed; thus when the marine acid is employed a genuine sea salt remains, when the nitrous, a quadrangular nitre, and when the vitriolic, a sal mirabile. The substance separated, joined to the mineral alkali, to the basis of sea salt, or the salt of kali, recomposes the borax again.

Thus we find borax composed of two principles—one everywhere plentiful, another which has not hitherto been obtained but from borax itself; the last in the smallest proportion. How far this peculiar substance is natural, of mineral or of vegetable origin, is wholly unknown. Borax comes from the East Indies in little crystalline masses, somewhat resembling small crystals of sal gem, mixed with earth and other impurities. Whether it is natural or artificial we have no satisfactory account; most probably it is in a great measure artificial, and the earthy matter mixed with it to make us look upon it as a fossil salt peculiar to the Indies. It is refined in Europe, but the process is also kept a secret. Some additional substances are generally supposed to be employed, the refined borax being in larger crystals than we can make this salt shoot by itself.

#### BORAX OF SODA.

[From the Elements of Natural History and Chemistry, M. Fourcroy, London, 1796.]

Borax of soda or common borax, is a neutral salt formed by the combination of the boracic acid with soda. We get this salt from the East Indies, but its history is very little known. We know not certainly whether it be a product of nature or art. The discovery of boracic acid existing in a state of solution in the waters of certain lakes in Tuscany, give us reason to think borax a product of nature. A variety of facts which we shall hereafter mention concur to show that this salt may be also formed by artificial processes as well as nitre. Borax of soda appears in commerce in three different states. In the first it is crude borax, tincal, or chrysocolia—this we get from Persia. It is in greenish masses which feel greasy, or in opaque crystals colored like green leeks, which are prismatic figures of six faces, terminating in irregular pyramids; there are even two kinds of these greenish crystals differing from each other in size. This salt is very impure, a great many extraneous substances being intermixed with it.

The second species, known by the name of *China borax*, is rather more pure than the former. It appears in the form of small plates or in masses, irregularly crystallized, and of a dirty white color. It displays the beginnings as it were of prisms and pyramids confounded together without any systematical arrangement; the surfaces of these crystals are covered with a white dust which is thought to be of an argillaceous nature.

The third species is Dutch, or refined borax; it appears in fragments of crystals transparent and tolerably pure. Pyramids with a number of faces are observed in it, but their crystallization appears to have been interrupted; its form affords a certain indication of the manner in which the Dutch purify this salt—it is by solution and crystallization. Lastly it is prepared in Paris by Messrs. Lefguillers, druggists, and their purified borax is in no way inferior in purity to the Dutch borax. Besides these four kinds of borax, M. La Pierre, apothecary in Paris, has imagined it to be formed in a mixture of soapsuds with dirty kitchen water, which a certain individual preserves in a kind of ditch, obtaining from it at the end of a certain time genuine borax, in beautiful crystals. But this fact, though first communicated to the public ten years ago, has not yet received confirmation.

We are still ignorant, therefore, in what manner borax is formed, only it seems to be produced in stagnant waters containing fat matters; some authors assure us that it is artificially composed in China by mixing in a trench, grease, clay, and dung, in alternate layers, watering this collection of matters at proper times, and leaving it untouched for several years; at the end of this time, by forming these matters into a livivium, crude borax is obtained.

Others would persuade us that it is got out of water filtered through copper ore. M. Baumé positively asserts that the former of these processes succeeded very well with him. \* \* \* We leave it in possession of the name of borax in order to distinguish it from genuine borate of soda, which is saturated with boracic acid. We likewise call it borax supersaturated with soda, to indicate the nature of the combination.

[From Thompson's Chemistry, 1818.]

#### BORATE OF SODA.

Of this salt there are two sub-species, namely: *borate of soda* and *borax*. This salt (borate of soda), which may be formed by saturating borax with boracic acid, has never been examined. Bergman informs us that about half its weight of boracic acid is necessary to saturate the borax. \* \* \* From the experiments of Wenzel, the proportion of its constituents seem to be, acid 100, base 44, but no confidence can be put in this analysis. Berzelius attempted to ascertain its composition, but met with difficulties which he was unable to surmount.

#### BORAX.

This salt, the only one which has been accurately examined, is supposed to have been known to the ancients and to be the substance denominated chrysocola by Pliny. \* \* \* Bergman was the first who demonstrated that it has an excess of base and is therefore a sub-borate. This salt is brought from the East Indies in an impure state under the name of "*tincal*," enveloped in a kind of fatty matter, which Vauquelin has ascertained to be a soap with soda for a base. When purified in Europe it takes the name of borax. The purification was formerly performed by the Dutch and of late by the British, but the process which they follow is not known. Valmont Bomare informs us that they extract 80 parts of pure borax from 100 parts of tincal. The operations are conducted in leaden vessels, and consist chiefly in repeated solutions, filtrations, and crystallizations. Valmont Bomare suspects that they employ lime water. The difficulty in refining tincal arises from the presence of a substance resembling soap, composed of a natural fatty body which surrounds the crystals.

#### REFINING OF NATIVE BORAX OR TINCAL.

Tincal was first refined in Venice, whence came the name "*Venetian borax*" as a distinction from "*tincal*" or "*crude borax*." The process was at a later period introduced into Holland and France by the Leucuyer Brothers. The process was preserved as a profound secret, yet a number of descriptions were published, of which the following are quoted:

The following is the improved mode of purifying borax: the crude crystals are to be broken into small lumps and spread upon a filter lined with a lead coating, under which a piece of cloth is stretched upon a wooden frame, the lumps are piled up to the height of twelve inches and washed with small quantities of a caustic ley of five degrees Beaumé (Specific gravity 1.033) until the liquor comes off nearly colorless; they are then drained and put into a large copper of boiling water in such quantities that the solution stands at twenty degrees Beaumé (Specific gravity 1.160); carbonate of soda equal to twelve per cent of the borax must now be added, the mixed solution allowed to settle, and the clear liquid syphoned



off into crystallizing vessels. Whenever the mother liquors get foul they must be evaporated to dryness in cast-iron pots and roasted to burn away the viscid coloring matter.

[From *Chaptal's Elements of Chemistry*, 3d American Edition, Boston, 1806.]

In order to purify borax nothing more is required than to clear it of the noxious substance which soils it and impedes its solution. Crude borax, added to a solution of mineral alkali, is more completely dissolved, and may be obtained in considerable beauty by a first crystallization, but it retains the alkali made use of; and borax purified in this manner possesses a greater portion of the alkali than in its crude state. The oily part of the borax may be destroyed by calcination. By this treatment it becomes more soluble, and may be purified in this way, but the method is attended with considerable loss, and is not so advantageous as might be imagined. The most simple method of purifying borax consists in boiling it strongly and for a long time. This solution being filtered, affords by evaporation crystals rather foul, which may be purified by a second operation similar to the foregoing. I have tried all these processes in the large way, and the latter appears to me to be the most simple.

[From *Knapp's Chemical Technology*.]

In one of these methods the impurities are removed by lime, the tincal being softened in a small quantity of cold water, and stirred about with a gradual addition of about one per cent of slacked lime. The turbid lime water is alternately poured off, and when the impurities have settled down on standing, the clear liquid is again poured upon the crystals, and this process repeated several times in this manner, the greater part of the soapy compound is removed, and what still remains is separated by dissolving the crystals in hot water, and adding about two per cent of chloride of calcium, chloride of sodium is formed, and an insoluble lime soap, which is removed by straining, and the clear liquid is evaporated to the consistence of twenty-one degrees Beaumé (=Specific gravity 1.169). The crystallization is effected in wooden vessels lined with lead, and having the form of short inverted cones. This shape is preferable, because the deposit which may form collects in the lower narrower part, and does not interfere with the crystallization.

The use of lime facilitates the clarification, but may occasion loss by the formation of an insoluble borate of lime, for which reason it cannot be very strongly recommended.

Clouet recommends the powdering of the tincal, which is next mixed with ten per cent of nitrate of soda, and calcined in a cast-iron pot. The fatty substance being thus destroyed, the calcined mass is dissolved in water, and the solution evaporated to crystallization.

#### ARTIFICIAL BORAX.

Crude boracic acid from Italy is principally sent to England and the United States, where a large proportion of it is manufactured into borax by combination with carbonate of soda artificially. This manufacture was commenced in England, in 1818, since which time the price of borax has steadily declined, while its uses in the arts have multiplied.

There are two varieties of borax, the octahedral, most desired in France, and the prismatic, largely made in England and America, and known as the borax of commerce.

Prismatic borax has the following composition:

Boracic acid	36.6
Soda	16.2
Water	47.2
	<hr/>
	100.00

Chemical formula,  $\text{NaO}, 2\text{BO}_3 + 10\text{H}_2\text{O}$ .

Prismatic borax crystallizes in the monoclinic system. The simple forms of this system are the right prism with rhomboidal base, and the oblique rhombic prism. Natural borax is always in this form. It is said that octahedral crystals have been seen in crude tincal from China, but this statement has not been verified.

The following figures of prismatic borax crystals are from *Hauy's Traité de Mineralogie*:



Fig. 1.

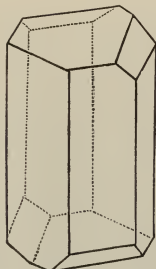


Fig. 2.



Fig. 3.

Prismatic borax is manufactured in England in the following manner: A solution of crystallized carbonate of soda is made in a lead-lined vat (*A*), figure 4, which is heated by steam from the boiler (*G*),

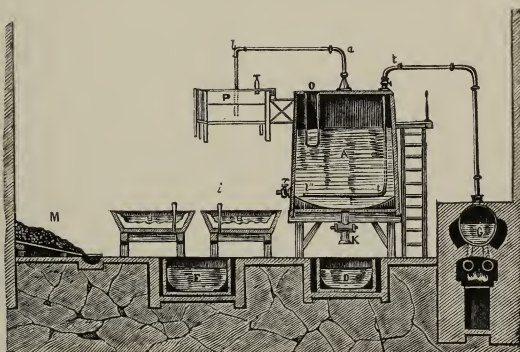


Fig. 4.

the quantity of steam required being regulated by the valve (*t*). The steam coil (*t'*) and (*t''*) is pierced with a multitude of small holes through which the steam escapes into the solution. This is called a *wet coil*, in contradistinction to a similar coil without holes, called a *dry coil*, used in evaporation, and in cases where it is undesirable to add water to the solutions. These terms will be used in all following descriptions.

When the charge of carbonate of soda is wholly dissolved, and the temperature has reached 212 Fahr., boracic acid is added portionwise, that effervescence may not cause the liquid to overflow the sides of the dissolving vat. When the required acid has been added, the vat is covered, and the temperature raised to 219–221 degrees, when the steam is shut off. The boiling solution should mark 21 to 22 degrees of Beaumé's hydrometer. If the solution should be too weak, a sufficient quantity of crude borax is thrown in; if the reverse, boiling water is added. The liquid is allowed to stand twelve hours, to settle, during which time the heat is kept up by a dry coil, through which steam is caused to flow. The clear solution is then drawn off through the cock (*r*) into the wooden lead-lined crystallizers (*B*). When the crystallization is complete, the mother liquors are drawn into the cast-iron receiver (*E*) by the openings (*i*), which are closed

by a long wooden plug, shown in the engraving. The crystals are removed and drained on the inclined plane (*M*), from which the mother liquor flows into a special receiver. The impurities which have formed during the solution in the vat (*A*) are drawn off through a large cock (*K*) into a cast-iron receiver (*D*).

The vapors arising from the boiling operation contain a notable quantity of carbonate of ammonia. They are conveyed by the pipe (*b*) to a covered tank (*P*) containing a dilute solution of sulphuric acid, by which they are absorbed and retained.

The usual charge is 26 cwt. (2,912 lbs) of carbonate of soda, dissolved in about 330 imperial gallons of water. To saturate this solution, 24 cwt. (2,688 lbs) of crude boracic acid are required. The crystallization generally requires two to three days, the mother liquors are returned to the boiling vat until they become too foul, when they are separately concentrated, the sulphate of soda they contain crystallized out, and the remainder evaporated to dryness and sold to the glass-makers.

A process, patented by Sautter, produces borax without the intervention of water. Thirty-eight parts of pure dry boracic acid are mixed with forty-five parts of pure dry crystallized carbonate of soda in powder. This mixture is placed in a room, heated to from 90 to 115 degrees Fahrenheit, on wooden planks, in layers of about an inch in thickness. This temperature is found sufficient to enable the boracic acid to expel the carbonic acid and excess of water from the carbonate of soda, and perfect borax, or baborate of soda, results.

Artificial borax is also extensively manufactured in France from Italian boracic acid. Nearly the whole produce of northern Italy is consumed there. The borax produced by the above processes is sufficiently pure for most commercial purposes, but the crystals are small and irregular, and there is a small excess of boracic acid. To correct these faults, a second crystallization is practiced, as follows:

The first process yields "crude artificial borax," and the latter, "refined borax of commerce."

The crude borax of the first operation is redissolved in a large lead-lined vat (*A*), fig. 5, which has a capacity of 18,000 pounds of

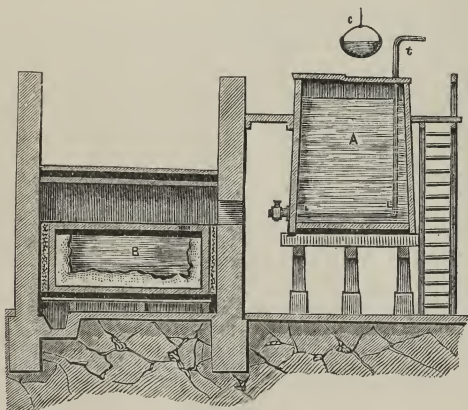


Fig. 5.

borax with the water required for its solution. The heat required is obtained in steam from a boiler, not shown, which is conveyed through the pipe (*t*) to the wet coil (*t' t''*).

The borax is placed in the iron basket (*c*), which is suspended by a chain, and allowed to sink just below the surface of the liquid in the vat. By this plan the solution takes place more rapidly, the more concentrated solution sinking to the bottom. The basket is refilled as fast as the borax dissolves, until the whole charge has been added. To each quintal of borax (112 pounds), 8 killograms (17.63 pounds) of crystallized carbonate of soda are added, to saturate any excess of boracic acid, after which the solution is brought up to the temperature of 212 Fahr. At this heat the solution should have a density of 21 degrees Beaumé (specific gravity, 1.169); if not, it must be brought up by the addition of more crude borax, or reduced with boiling water, as the case may be.

The solution is then drawn off into the crystallizer (*B*), which has the capacity to receive the entire contents of the boiling vat. The crystallization must be slow to insure large and perfect crystals of borax. To this end the crystallizing vat must be kept warm by covering closely, and sometimes by surrounding it with spent tan bark, or straw mats. In twenty-five to thirty days the temperature has become reduced to 77 to 86 degrees Fahr., when the mother liquor is drawn off and the crystals broken down and removed by the aid of hammer and chisel.

The result is the ordinary prismatic borax of commerce. To obtain octahedral borax, the solution is made in the same way and in the same apparatus. The solution is brought up to 30 degrees Beaumé (specific gravity, 1.261), at the temperature of 212 Fahr., at which stage it is quickly run off into the crystallizer, covered and left for a time undisturbed. When the temperature has fallen to 174 Fahr., the mother liquors are drawn off, to prevent a deposit of prismatic crystals on the octahedral borax, the primitive form of which is shown in fig. 6.

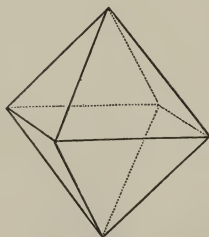


Fig. 6—Octahedral Borax.

When drawn into suitable vessels the mother liquors deposit a copious crop of prismatic borax, which may be redissolved or utilized as such.

Octahedral borax contains but five equivalents of water, and is consequently richer in the other constituents than prismatic borax. The following is the percentage composition of this salt:

Borax	69.36
Water	30.64
	<hr/> 100.00



The following is a translation of a portion of a letter from D. Gernez, *Professeur au Lycée Louis Le Grand et à l'Ecole Centrale Des Arts et Manufactures*, dated Paris, September 28, 1874, in answer to inquiries relating to the manufacture of borax when but little was known on the subject in California. Professor Gernez is high authority on this subject:

The least hydrated variety is the most esteemed in commerce here. It may be obtained by the following method: Dissolve the borax in water, kept at the temperature of 100 centigrade by a jet of steam, in a wooden bucket lined with lead, until the solution be sufficiently concentrated to mark at least thirty degrees by Beaumé's areometer. Let the liquid remain at the same temperature, without disturbing, in order that it may be freed from the insoluble impurities which it contains. Pour the hot liquid into a large covered vessel in which it can cool slowly, and if you desire the crystallization to commence in a large number of points, as soon as the temperature has reached eighty degrees centigrade throw on the liquid the powder of borax, which you can obtain by roughly pounding some pieces of borax of the variety you wish to obtain.

Each grain of the crystalline powder will grow larger and give voluminous crystals which will be the only ones of their kind, while the temperature remains above sixty degrees, and which will be the only ones at a still lower temperature if the crystallizers are perfectly covered and protected from the crystalline powder of the other variety of borax.

If the crystallizers are not well covered it will be necessary to draw off the liquid at this temperature. The mother liquors will give, in cooling, the variety of borax richest in water and that which is less valued. If, on the contrary, the crystallizers be well covered, and the operation conducted on a large scale with the care that can be devoted to it on a small one in the experimental laboratory, by cooling the solution even below sixty degrees, and up to the ordinary temperature, only octahedral borax will be obtained.

None of the difficulties attending the refining of crude natural borax are met with in these operations. When the manufacture of artificial borax commenced in Europe from Italian boracic acid, the crystals were so white and pure that the consumers did not believe it to possess the strength of the dark colored article from the Dutch refineries they were in the habit of using, and this prejudice was so great that the new article did not find a ready sale. It is said that borax was sent to Amsterdam and shipped back to France as Dutch borax before it could be sold.

#### SOLUBILITY OF BORAX IN WATER.

TEMPERATURE.		100 parts of Water Dissolves Anhy- drous Borax, Parts.	100 parts of Water Dissolves Prismatic Borax $\text{Na}_2\text{O}$ , 2 $\text{BO}_2$ +10 $\text{HO}$ , Parts.
Cent.	Fah.		
0	32	1.49	2.83
10	50	2.42	4.65
20	68	4.05	7.88
30	86	6.00	11.90
40	104	8.79	17.90
50	122	12.93	27.41
60	140	18.09	40.43
70	158	24.22	57.85
80	176	31.17	76.19
90	194	40.14	116.66
100	212	55.16	201.43

Borax was accidentally discovered in California in 1856 by Dr. John A. Veatch. The following letter from that gentleman is a history of his discovery, and is quoted in full:



## LETTER FROM DR. JOHN A. VEATCH TO THE BORAX COMPANY OF CALIFORNIA, JUNE 28, 1857.

Since the demonstration of the existence of boracic acid and the borates in California, in quantities sufficient for commercial purposes, a history of the discovery and a description of some of the more important localities of these useful products become matters of some interest.

I believe I was the first to detect the borates in mineral waters in this State, and perhaps, as yet, the only observer of their localities. My attention was first drawn to this subject by noticing crystals of borate of soda in the artificially concentrated water of a mineral spring which I chanced, at the time, to be examining for other matters. This water was from one of the several springs since known as the "Tuscan Springs," and which have gained some fame, and very justly, I believe, as medicinal waters. The spot has been described by Dr. Trask under the name of the "Lick Springs," and is so designated on Britton & Rey's late map—lying in the north part of Tehama County, eight miles east of Red Bluff. The crystals alluded to were observed on the eighth day of January, 1856. Several pounds were subsequently extracted by evaporating the water to a certain degree of concentration and allowing the borax to crystallize. The pioneer specimens of this product were deposited in the Museum of the California Academy of Natural Sciences, as an evidence of the existence of a new and important link in the chain of our mineralogical productions, showing that along with the rich productions of the noble and useful metals, we have also the mineral substance so essential to their easy application to the purposes of man.

The water holding in solution so valuable a product was thought worthy of a critical analysis, and consequently at an early period the aid of a chemist of this city was invoked. The reported result, which I placed at the disposition of Dr. Trask, was thought worthy of a place in his Geological Report of that year, and appears in it. I, however, subsequently learned, to my chagrin, that the analysis was totally unreliable; but as the brilliancy of its promised results, unreal as they were, led me to further and happily successful investigations, I forgive the blundering incompetency of the chemist.

My mind being now alive to the subject, I learned upon inquiry, of other localities, which I supposed might yield the borates. One of these, near the mouth of Pit River, forty miles north of the Tuscan Springs, I had the pleasure of visiting in company with Dr. Wm. O. Ayers, in April, 1856. Specimens there obtained yielded the borate salts; and from a subsequent examination of the intermediate country several similar localities were found. The quantity was too small to be of any practical importance, but the prevalence of the salt gave encouragement to further search. A reconnaissance of the "Coast Range" of mountains, from the neighborhood of Shasta, over a length of some thirty miles toward the south, brought to light borates in the numerous salt springs abounding in that region, but only in minute quantities. These springs were found almost exclusively in the sandstone, or the magnesian limestone overlaying it, and the borates especially seemed to abound in localities bearing indications of volcanic disturbance. Thus a kind of guide was obtained in the prosecution of further explorations. I began to entertain hopes of finding larger streams with stronger impregnations, or accumulations of the borates, in salt lagoons said to exist in Colusa County, where the sandstone formation was largely developed, the adjacent foothills presenting volcanic features. Hunters told tales of mineral springs of sulphurous and bitter waters; of lakes of soda, and alkaline plains, white with efflorescent matters in that region. Not being in a situation immediately to visit these inviting localities I had, for the time, to content myself with pointing out to hunters and others occasionally passing through that country such appearances as I wished particularly to be noted. Their reports, together with specimens sometimes furnished, were all corroborative of the correctness of my theory. Col. Joel Lewis, of Sacramento City, who occasionally visited the Coast Range on hunting excursions, and to whom I explained the object of my search, and who, though not a scientific man, is an intelligent observer, had the kindness to look in his peripatinations for certain indications. He subsequently informed me by letter that he had met with an Irishman, living in Bear Valley, who had found a "lake of borax," as it was pronounced by an Englishman who lived with the Irishman, and who had been at one time employed in a borax manufactory in England, and therefore assumed to speak knowingly on the subject. He also informed me in the same letter that a Major Vanbibber, of Antelope Valley, had discovered large quantities of nitre in the same neighborhood. These glowing reports led me to hasten the excursion I had so long contemplated. In a personal interview with the Colonel he told me of an enormous mass of a white pulverulent substance he had himself observed near the margin of Clear Lake, of the nature of which he was ignorant. Mr. Charles Fairfax, who was with the Colonel at the time, stated to me that a small rivulet running at the base of the white hillock was an intensely impregnated mineral water, totally undrinkable, as he had accidentally discovered by attempting to slake his thirst with it. From the meager information gathered from these gentlemen I was led to hope the "hill of white powder," as they termed it, might prove to be borate of lime. I determined to satisfy myself by a personal examination at once, and I finally induced Col. Lewis to act as my guide, by furnishing him with a horse and paying expenses. It was some time in the early part of September, of last year (1856), that he and I left Sacramento for the localities that had so much excited my hopes. At the town of Colusa, which we reached by steamer, horses were obtained, and we proceeded in a westerly direction across the Sacramento Valley to the foothills of the coast mountains, a distance of about twenty-five miles. That portion of the plain skirting the hills gave unmis-

takable evidence of a heavy charge of mineral salts, and the exceedingly contorted and interrupted state of the hill strata enabled me at once to predict the presence of the beloved borates, which chemical trial on some efflorescent matter taken from a ravine proved to be the case in a slight degree. At this point we entered "Fresh Water Cañon," which cuts the hills and forms a passway into Antelope and Bear Valleys. Here I received information from a settler, of a hot sulphur spring a few miles south of Bear Valley on one of the trails leading to Clear Lake. This spring we succeeded in finding on the following day. It was with no small pleasure that I observed the outcropping magnesian limestone in the hills surrounding the valley of the springs. The strong smell of sulphuretted hydrogen and the appearance of a whitish efflorescence on the rocks manifested, even at a distance, almost the certainty of finding the mineral I sought. The indications were not deceptive. The efflorescence proved to be boracic acid in part, while the hot sulphurous water held borate of soda in solution, together with chlorides and sulphates.

There are three hot springs at this place and several cold ones, all alike strongly impregnated with common salt and borax. The quantity of water yielded, in the aggregate, is about one hundred gallons per minute, the hot and cold springs yielding about equal quantities. The temperature of the hot water is 200° Fahr., and that of the cold 60° Fahr. The same phenomenon occurs here that is observed at the Tuscan Springs, viz.: free boracic acid in the efflorescence on the margin of the springs, while the water itself shows a decided alkaline reaction. A careful examination proves that the efflorescent matters come directly from the water of the springs, taken up by capillary attraction of the soil and evaporated by the air. The singular fact may be accounted for by the decomposition of the borates by sulphuric acid generated by atmospheric action on the sulphur in which the soil abounds; or the same decomposition may be produced by the hydrosulphuric acid passing up in gaseous form from the laboratory Nature has established beneath. The same action doubtless takes place in the water; but the boracic acid set free is at once taken up by the excess of alkaline matter while in the efflorescence; no fresh supply of alkali offering, the acid remains in its free state when once displaced by more powerful acids.

These springs seem to be identical in the character of their waters with the Tuscan Springs, and therefore doubtless possess the same extraordinary medicinal virtues.

As a source of borax these springs could be made available. But as the owners of this locality possess others of superior richness, it is not likely to be even called on to yield its mineral treasures. The situation is a pleasant and romantic one, and might be made a valuable watering place. The distance from the town of Colusa is thirty-five miles, over mostly a smooth and pleasant road. From Clear Lake it is eighteen miles, and over a rather rough country. The Indian name of the place is Co-no-to-tok, a generic word having reference to the white appearance of the ground. Mr. Archibald Peachy located a three hundred and twenty acre school land warrant on this place on behalf of the borax company.

After satisfying myself with the examination of this interesting spot, we proceeded at once to Clear Lake, noting nothing of interest save a "soda spring," the water being impregnated to a remarkable degree with carbonic acid gas, about eight miles from the lake. A chemical test also detected boracic acid in small quantity. The following day we reached the "hill of white powder," the goal of our hopes, on the margin of Clear Lake. This "white powder hill" proved an illustration of how little the recollections of mere casual observers are to be depended upon. The hill, in place of consisting of materials in a state of disintegration, so as to admit of being "shoveled up," as my friends supposed, proved to be a concrete volcanic mass, bleached white by sulphurous fumes, and looking at a little distance like a huge mass of slaked lime, which the unattentive observer might readily suppose to be "a hill of white powder." The hope of a treasure, in the form of borate of lime, vanished forever!

The road had been rather toilsome, the weather excessively hot, and my guide not very well, and as he had gone the full length of the contemplated journey and felt somewhat disgusted at the result so far, and had nothing more to draw his attention in this direction, he proposed to return at once by way of the Irishman's "borax lake" and Van Bibber's nitre placer. This was agreed upon. So, collecting a few specimens of efflorescent matter from the ground and filling a bottle with water in the ravine, I closed the examination of the "hill of white powder." The ravine I afterwards called the "boracic acid ravine," and the white hill is now called the "sulphur bank." Of these I shall have occasion to speak hereafter.

Before leaving the neighborhood, I determined, however, to know something more of its surroundings. I learned, upon inquiry of Mr. Hawkins, who lives near the spot, that a place not far off known by the name of "Alkali Lake," presented a rather peculiar appearance. Hawkins consented to act as my guide. After traveling a short distance and clambering to the narrow edge of an almost precipitous mountain ridge, we looked down the opposite slope, equally steep, on a small muddy lake, that sent up, even to our elevated position, no pleasant perfumes. Thus, on one of the hottest days September ever produced, without a breath of air to dilute the exquisite scent exhaled from two hundred acres of fragrant mud, of an untold depth, I slid down the mountain side into "Alkali Lake," waded knee deep into its soapy margin, and filled a bottle with the most diabolical watery compound this side of the Dead Sea. Gathering a few specimens of the matter incrusting the shore, I hastened to escape from a spot very far from being attractive at the time, but which I have since learned to have no prejudice against. Of this place I shall have occasion to say more.

On my return to Hawkins', who had the kindness to entertain me with the genuine hospitality of a frontiersman, I looked to my last specimens, and found encouraging results in the partial chemical examination I was able to give them.

I now again placed myself under the guidance of my friend Lewis, and we started for the Irishman's house in Bear Valley. We found the owner of the "borax lake," but the borax had evaporated with the water, and left nothing but common salt tinged of a beautiful bluish red color, which I suppose had given the notion that it was something out of the usual way. It was the only specimen of salt I remember to have seen in the Coast Range that contained no boracic acid in any form; it was guiltless of even a trace.

The next step was to examine the nitre region. Major Van Bibber, the reputed discoverer, being a grandson of Daniel Boone, ought to possess, one would suppose, an hereditary knowledge of one of the essential constituents of gunpowder; and as Colonel Lewis had shown me a specimen of very fine pure nitre, which he said the Major had given him, I rather expected to find a "few more left." This, however, was rather worse than the "borax lake" disappointment. The Major had absolutely forgotten where the place was, and whether there were any more specimens than those he gave Lewis. The Major, I believe, must really have forgotten, for, upon subsequent examination, the specimens proved to be refined saltpetre, that undoubtedly came from some shop or drug store. There was certainly a mistake about its origin; but I felt amply repaid for a hard day's ride in spending a night under the hospitable roof of a direct descendant of the renowned "backwoodsman of Kentucky." I observed near the Major's house, a small salt pond. Some salt crystals I picked up had the peculiar beveled angles indicating the presence of borax. The quantity was inconsiderable. Thus ended my first expedition to Clear Lake. We here set our faces direct for Colusa, as there seemed nothing more to be seen, and as I had engaged the horses we rode at rather a high per diem, I felt anxious to terminate the trip. From Colusa my guide returned to Sacramento, and I to Red Bluff. From there I came again to San Francisco for the purpose of testing my specimens more critically than I was able to do in the country. The minutiae of the above trips may not interest the company, but I have personal reasons for setting forth *all the facts exactly as they occurred.*

Convinced of the richness of my "alkali lake" specimens, it remained to be seen whether the quantity was sufficient to justify the hope of making it available for practical purposes. A further and more strict examination was necessary. I felt, too, the propriety of a thorough exploration betwixt the Bluff and Clear Lake, and thence to the Bay of San Francisco, thus rendering continuous the reconnaissance from Pit River to the last named point, a distance, in a direct line, of two hundred miles. After a hard struggle for the funds requisite, I returned to Red Bluff, and from thence, in company with my son, commenced a pretty thorough examination of the Coast Range and the adjoining edge of the Sacramento Valley.

Nothing of much importance presented itself until reaching a saline district, about eighty miles south of Red Bluff. It is on one of the branches of Stony Creek. Valuable salt springs exist here. The waters contain the borates in minute quantities, and one spring was remarkable for the enormous proportion of iodine salts held in solution. In our slow onward progress borax now and again manifested itself, but as it had grown familiar I no longer went into ecstasies over a mere trace. I still treated, however, the slightest indications with due deference and noted their localities.

In due time, I again reached the "white hill." The disgust of the first disappointment had worn off and I felt disposed to reexamine the locality rather more critically. I now discovered, for the first time, that the "white hill" was mostly a mass of sulphur fused by volcanic heat. The external crust, composed of sulphur mixed with sand and earthy impurities, formed a concrete covering of a whitish appearance, hiding the true nature of the mass beneath. On breaking the crust, numerous fissures and small cavities lined with sulphur crystals of great beauty were brought to light. Through the fissures, which seemed to communicate with the depth below, hot aqueous vapors and sulphurous fumes constantly escaped. The fused mass, covering many acres and exhibiting a bluff front some forty feet high, is exceedingly compact and ponderous in structure, of various shades, from yellow to almost black. It seems to be very pure sulphur. The quantity is enormous and at no distant day may be made available.

From the "sulphur bank" I again turned my attention to the ravine. The water, as I had before ascertained, was strongly impregnated with boracic acid in a free state. The stream is small, yielding only about three gallons per minute, and is soon lost in the sandy soil, in its progress toward the margin of the lake. From the porous nature of the ground surrounding the spring, and saturated with the same kind of acid water, it is probable a large quantity escapes without making its appearance on the surface. The soil for some yards on either side of the ravine is covered to the depth of an inch or two with boracic acid in Summer. Sulphuretted hydrogen escapes in continued bubbles through the water—a feature common to all the borax localities I have yet found; in some places, however, the carburetted takes the place of the sulphuretted hydrogen. The head of this ravine is about three hundred yards from the margin of Clear Lake, winding round the base of the "sulphur bank," receiving some small springs in its course, which seem to have their origin beneath the sulphur. The flat land bordering the lake, some eight acres in extent, through which the ravine runs, shows a strong impregnation of boracic acid in its soil. The point where the ravine enters the lake is marked by a large quantity of water of a boiling temperature, issuing through the sand a little within the margin of the lake. This percolation of hot water covers an area of one hundred and fifty by seventy-five feet. This fact I observed on my second visit, but not until the third or fourth visit did I ascertain that the water contained a considerable quantity of borax, along with an excess of boracic acid. From a gallon I obtained four hundred and eighty-eight grains of solid matter, consisting of borax, boracic acid, and a small portion of silicious and other earthy impurities. On digging to a slight depth, just outside the lake, the hot water burst up and ran



off freely. From one of these places a stream issued of sixty gallons per minute. I have estimated the entire quantity at three hundred gallons per minute, and feel very confident of being largely within bounds. The stream seems to come from the direction of the sulphur bank, and it would probably be easy to intercept it before it enters the lake by digging a little above high water mark. It may be well to note here that the difference betwixt high and low water marks in Clear Lake is never more than three feet.

The enormous amount of borax these springs are capable of yielding would equal half the quantity of that article consumed both in Europe and America. The large quantity of water in which it is dissolved would, of course, involve the necessity of extensive works for evaporation. Graduation, as a cheap and effective method of evaporation, would be exceedingly applicable here, from the continued prevalence of winds throughout the entire year. These winds, blowing almost unceasingly from the west, form a peculiar feature of the country about Clear Lake. There is nothing to hinder the manufacture of many millions of pounds of borax per annum, at a cost but little beyond that of producing salt by graduation. Fuel, for final evaporation, could be had in any quantities from the extensive oak forest in the immediate vicinity.

With these observations I dismiss this locality; adding, however, that Mr. Joseph G. Baldwin located this with a 480-acre school land warrant, for the benefit of the borax company.

Having wandered from the story of my second visit to the "sulphur bank," and blended it with observations made in several subsequent examinations, I turn now to my second visit to "Alkali Lake," or "Lake Kaysa," as the Indians call it. I need only to say, however, that on this occasion I became fully satisfied of the great value of the locality, the extent of which has only recently been developed. I observed that the lake itself contained but little water, but that wells, dug anywhere near its margin, immediately filled with the same kind of water; the conclusion, therefore, was that an almost inexhaustible supply was obtainable. I learned, too, that what seemed to be mud at the margin, and shelving off and covering the entire bottom to the depth of some feet, was a peculiar, jelly-like substance of a soapy feel and smell. This matter I found to be so rich in borax that I supposed it might be advantageously used for the extraction of the mineral. Thus satisfied of the value of the lake, I little thought that within a few yards of me lay an additional value in the form of millions of pounds of pure borax crystals hidden by the jelly-like substance I was then contemplating. This important fact was not observed until some six months afterwards.

This locality is by far the most important I have yet discovered. It is situated in the angle of two prongs into which Clear Lake is divided at its eastern extremity. The elevated hill land that fills the angle separates into two sharp ridges, each following its division of the lake, and leaving a valley between them of a triangular shape, near the apex of which lies "Alkali Lake." Clear Lake is, therefore, on two sides of it, distant to the north about a mile, and to the south about half the distance. The open part of the triangular plain looks to the east, and expands into an extensive valley, from which it is cut off partially by a low volcanic ridge, running across from one hill to the other, and thus inclosing the triangle. This ridge is composed of huge masses of rock, resembling pumice stone, which floats like cork in the water. A thin stratum of ashy-looking soil, scattered over with obsidian fragments, cover the ridge, and affords root to a stunted growth of manzanita shrubs.

The whole neighborhood bears marks of comparatively recent volcanic action. Indeed, the action has not ceased yet, entirely. Hot sulphurous fumes issue from several places on the edge of the ridge just named, on the side next the Alkali Lake.

The "lake," as it is called, is rather a marsh than a lake, in Summer. In Winter it covers some two hundred acres with about three feet depth of water. In the dry portion of the year it shrinks to some fifty or sixty acres, with a depth of only a few inches. The "soapy matter" covers the entire extent with a depth of nearly four feet, the upper part for a foot in depth being in a state of semi-fluidity, the lower having the consistency of stiff mortar. Beneath this is a rather tenacious blue clay, the depth of which is as yet undetermined. It has been penetrated fifteen feet with but little change in appearance. Probably beneath this lies the great fountain of intensely charged mineral water forming the lake, the supply of which must come from below, as there are no visible springs running into it. It has no outlet, and never goes entirely dry. A six-inch auger bored into this clay, at a depth of eight feet, struck a stream of water yielding eight gallons per minute, accompanied with a jet of carburetted hydrogen gas. This water was nearly as highly charged with solid matter as that of the lake in its highest Summer concentration; the proportion of borax to the other substances being greater. The soapy or gelatinous matter, however, presents the greatest feature of attraction, being filled with the prismatic crystals of pure borax. They vary from a microscopic size up to the weight of several ounces. These crystals are semi-transparent, of a whitish or yellowish color. The form is an oblique, rhomboidal prism with replaced edges and truncated angles. In some cases the edges are beveled, and in others the unmodified hexahedral prism exists. Beneath the gelatinous matter, on the surface of the blue clay, and from six to eighteen inches in it, crystals of a similar form, but of a much larger size, are found. They weigh from an ounce up to a pound, and seem to have been formed under different circumstances from the other crystals. My first impression was they had been formed in the upper stratum, and sinking by their own gravity had found their present position. An examination proves, however, that they were formed where they lie, as particles of the blue clay are found inclosed in their centers, which could not have been the case had the upper crystals been their nuclei, for no blue matter is ever found in them.

It is much to be regretted that explorations have not yet been made beyond the depth of this blue clay stratum. Many important results may be anticipated from such examination. The

great source of supply might be reached, and, although the water might not contain more borax, the alkaline matters so redundant at the surface would probably be less, and the difficulty of separation be consequently decreased. From the constant escape of inflammable gases over the whole extent of the lake, there is nothing improbable in the supposition that boring to a moderate depth would give exit to a quantity sufficient to answer as fuel for evaporating the water. The same thing occurs in some portions of the United States—gas being used as fuel for extensive salt works. I hope to be excused for theorizing a little as it is intended to point to practical results. I will now confine myself to facts.

The first inquiry of practical interest relates to the quantity of borax already formed. On this subject I cannot speak with perfect confidence. The quantity is very considerable, but I do not look on the experiments heretofore made to test this matter as conclusive. The area covered by the crystalline deposit is not co-extensive with that of the lake, but has been found over a space of about twenty acres in the examination made so far. It will probably be found to cover the same space the water does at the driest season—say fifty acres. The crystals are not indiscriminately dispersed through the soapy or gelatinous matter, but lie in strata of various thickness, from half an inch to six inches, parted by intervening layers of the soapy matter, and varying from one to six in number. In passing over them in a boat a stick thrust down sometimes requires great force to drive it through, while in other spots it enters with little resistance, proving a great irregularity in these crystalline strata. The lower or blue clay stratum of large crystals consists of but one layer of variable thickness. Two experiments alone have been made to ascertain the quantity in a given space. Dr. Ayres sunk a coffer dam three feet square at a point he supposed to be of medium richness, and extracted therefrom one hundred and sixty-three pounds of crystals. I subsequently put down a coffer of the same dimensions at a point I supposed to be the poorest, as no crystals could be felt by thrusting down a stick, and obtained one hundred and one pounds. Taking the mean between these as a datum we should have 638,880 pounds as the product of one acre. The large crystals form about ten per cent of the whole.

Whether these crystals when removed would be replaced by others, so as to afford an annual supply, is a question of great practical importance. But as experiment alone can settle this, we will suppose, as the safer ground, that the crystals would not be replaced. We will assume, too, that the lake water is exhaustible and dependence must be placed on wells—is it likely a sufficient supply can be thus obtained? I think there is no hesitancy in answering this query in the affirmative. The well already dug yields eight gallons per minute, equaling 4,204,800 gallons per annum. The water holds in solution 12,480 grains of solid matters to the gallon, or two pounds and ninety-six grains. Assuming twenty per cent of the matters to be borax, which I believe to be not above the truth, the yield would be largely over a million and a half of pounds per annum from this one well. A few such wells would supply borax enough for the world.

To remove the borax from the complex solution, of which it forms the least soluble portion, crystallization presents the easiest and most effectual mode. To obtain this result, the excess of water must be expelled. Graduation would be scarcely applicable to water concentrated as this and boiling would have to be resorted to. The excess of water would be about five pounds to the gallon, thus leaving three pounds of water to hold two pounds of matter in solution for crystallizing. If it be required to operate on a given quantity of water in a given time, say one gallon per minute, a boiling surface of ten square feet would be necessary. Five pounds of water per minute would equal 7,200 pounds per twenty-four hours, requiring the consumption of 2,400 pounds of oak wood, or about three quarters of a cord. The solid matter would equal 2,880 pounds held in solution by 540 gallons of water. A crystallizing tank eight by ten feet, and one foot in depth, would be wanted to contain it. Should the borax equal only twenty per cent of the other matters, we should have 575 pounds as the result of the evaporation of one gallon per minute. Fuel is abundant and would cost two dollars and fifty cents per cord. In this calculation we have the elements of cost of manufacturing borax. The entire expense would probably not reach one cent per pound. The heaviest item of the whole would be the land transportation to the point of shipment—a distance of fifty-five miles. This would cost about one and a half cents. We might, upon the whole, safely calculate three cents as covering all expense upon the article laid down in the City of San Francisco.

A very valuable collateral product, iodine—with the compounds of which the water seems to be exceedingly rich—could be made a source of revenue with but little additional expense. With regard to the quantity of iodine, I cannot speak positively, not having isolated the product; but from the brilliant reaction with the qualitative tests, there can be no doubt of its being great. Should this article be manufactured largely, the sulphuric acid required might be made on the spot, from the products of the "sulphur bank," one and a half miles distant. With this, I leave Alkali Lake. I would state, that I located this place in my own name for the company.

There is yet another important borax locality in the same vicinity, resembling much the foregoing in its more prominent features. It consists of a pond of water of about twenty acres. The bottom is covered with the same soap-like substance, but seems to contain no crystals. The water contains less solid matter in solution, but the percentage of borax is greater in proportion to the other substances than in the Alkali Lake. The borax separates readily by crystallization, and forms about thirty-three per cent of the whole matter. Like the foregoing, this pond has no outlet and no visible source of supply, yet it is said never to be dry, although the water is never more than three feet deep. It would, perhaps, be a profitable source of borax, if the millions of pounds the before described localities are capable of yielding, be not



enough to supply the demand. It is in the midst of a magnificent grove of pines and oaks. The place was taken up by Mr. Archibald Peachy for the borax company, by the location of a 320-acre school land warrant.

The borates are also known to exist in other localities betwixt Clear Lake and Napa City. In Siegler Valley there is a hot spring in the waters of which I detected borates of strontia and other borate salts. Near Napa there is a borate spring, and one in Suisun Valley, near the marble quarry. None of these places are important.

The foregoing are the only borax localities known in the northern part of this State, and I feel confident there are no others in that quarter that can ever compete with the inexhaustible stores of "Alkali Lake" and the "Hot Springs."

I had expected to find something worthy of attention at or in the neighborhood of the Geysers. But there was no trace of borates in the hot waters of those springs, nor anywhere in the surrounding district. The geological features of the country were so different from that where I had heretofore found the borates, that I was able to predict, as soon as I saw it, that nothing of the kind existed.

In a hasty reconnoissance of the great Tulare Valley, I found traces, but nothing more, of these substances. I have reasons for doubting the existence of any large quantities in that region. That portion of the valley bordering on the Coast Range might be worth examining further. It is there, if anywhere, valuable deposits may be looked for.

There are probably as many as three districts in the lower part of the State, presenting the borates. One or more valuable localities may probably be found among them. As I expect soon to visit that portion of the State, I hope to be able at an early day to present to my friends of the borax company any valuable information I may there gain touching their interests.

Truly and respectfully yours,

JOHN A. VEATCH, M. D.

Borax was for a time successfully manufactured at the borax lakes in Lake County, under the superintendence of Dr. William O. Ayers, until the discovery of the vast fields of Nevada, followed by a speculative over-production, which, while it gave to the world an abundance of that useful, but before rare and costly mineral product, ruined nearly every person or company engaged in its exploration, manufacture, or sale. The history of the California borax lakes has been lately given to the world in an able article by Dr. Ayers in the Popular Science Monthly, a portion of which is quoted below:

#### BORAX IN AMERICA.

[By W. O. AYERS, M. D.]

Borax Lake and Hachinham [pronounced *Hah'-chin-ha'-ma*], both lie in the immediate vicinity of Clear Lake, about eighty miles north of San Francisco.

Borax Lake is a shallow pool intensely of alkaline water, without inlet or outlet, and of course its extent depends on its reception of rain water. After an exceptionally wet season it has a length of perhaps a mile and a half, with a depth of eight or ten feet; after an exceptionally dry season, on the contrary, it shows sometimes no water, the muddy bottom being covered with saline incrustations. When it has a length of three fourths of a mile, with a depth of four feet, being perhaps its average condition, the water holds in solution 18.75 grains of solid matter to the ounce—0.39 of its own weight. This consists of salts of soda, in the following proportions:

Sodium carbonate-----	61.8
Sodium chloride-----	20.4
Sodium baborate-----	17.8
	<hr/>
	100.0

But this alkaline water, exceedingly rich as it is in borax, constitutes only a trifling part of the commercial value of the lake. In fact, it has never been turned to account at all in the manufacture of borax, though such use of it is entirely practicable, as the statements to be presently made in relation to Hachinham will show. The muddy bottom of the lake was found, immediately on its discovery in 1856, to contain borax in crystals, in quantities most astonishing.

These crystals, being tested by various workers in iron and steel, were pronounced equal to the very best of refined borax. They are, in fact, pure borate of soda, without any other impurities than the mud mechanically entangled with them in the process of crystallization. They correspond to the native borax of other localities, designated as *tinical*, but yet are decidedly distinct from it. In fact, no such crystals as those of Borax Lake have ever been found in any other locality, and there are several points in connection with their mode of formation, and even their very existence, which are by no means easy of comprehension, as we shall see.

# EXPLANATION.

● Borax fields of unknown value.

◆ Borate of lime.

● Borax first discovered in California.

○ Deposit of borax first successfully worked in California.

◆ Borax fields now being worked.

● Boracic acid.

□ Sandy or desert lands, with isolated or irregular mountain ranges, generally rich in minerals. The soil, while it is to a great extent sandy and shifting in its character, only requires water to make it fertile. The plains are generally destitute of vegetation, but the mountains are especially supplied with timber. This colored portion is especially the silver region of California, and is rich in borax minerals.

*Henry S. Hanks*  
State Mineralogist

SKETCH MAP  
OF  
**CALIFORNIA'S BORAX**  
showing the Locality  
of  
THE PRINCIPAL BORAX FIELDS  
to accompany  
THE THIRD ANNUAL REPORT  
OF THE  
STATE MINERALOGIST OF CALIFORNIA  
1883

NEW BRITAIN & NEW S.F.

PHYSICAL  
SCIENCES  
LAB.



Although the discovery was made, as already stated, in 1856, no practical development of the lake was begun until 1864. From this time it was pressed vigorously until 1868, when it ceased, not from failure of the supply, but simply from mismanagement of the work. The crystals were certainly less abundant at the last than in the earlier workings, but the lake still held and doubtless holds now an amount running to many millions of pounds, if it be not in truth practically inexhaustible.

Their abundance was such, and the yield was so great, that within the period specified the lake had revolutionized the borax trade of the United States; in fact, it had accomplished that work before the close of the year 1864. The annual importations since 1855, the earliest date at which the Congressional reports enable us to trace them, had varied from \$143,218 to \$217,944. In 1864 they were suddenly reduced to \$8,984, a result due entirely to the working of Borax Lake.

A statement of the manner in which the crude crystals were removed and utilized will bring to our notice the strange peculiarities of their nature, origin, and mode of crystallization.

The mud which constitutes the bottom of the lake is a smooth, even, plastic clay, of unknown depth. It has been bored through thirty feet without showing change in its structure. The upper portion, for four and a half to five feet, holds unnumbered crystals; at that depth they suddenly and abruptly cease. Abundant explorations demonstrated that none were to be found any lower, and the daily working came to recognize the fact as established. The mud below that was saturated with the salts of soda, such as held by the water of the lake, but no distinct crystals existed.

The crystals of borax, in the upper portion, were removed by means of cofferdams. Each dam consisted of a box, without top or bottom, four feet square and six feet deep, made of thin boiler iron, suitably stiffened with surrounding bands of heavier iron. These dams, suspended above the water, between large pontoons or floats, were allowed to drop suddenly, whereupon their force of descent drove the sharp lower edge down through the soft mud and into that which was sufficiently firm and tenacious to resist the impact, and to render thus the iron walls of each a true cofferdam, from which the entire contents could be easily removed.

The water was first pumped or bailed out, till it became too thick to flow easily, and the remaining mud was lifted in tubs, in true mining style, and thrown into large troughs, where, being subjected to constant agitation in streams of the lake water, it was washed away, the borax being retained by its superior gravity.

No crystals were found until from twelve to fifteen inches in depth of the most fluid mud had passed away. The mud then began to feel "gritty," as the workmen expressed it, the "grit" consisting of multitudes of most exquisitely perfect minute crystals of borax. These crystals, like all those in the lake, were lying loose, detached from each other, attached to nothing by the base, and consequently perfect at both ends. It is not meant by this that every crystal was absolutely complete in every angle, but that they all had the tendency to the theoretical type, symmetrical at each end (a form which in artificial crystallization we scarcely ever reach, except by accident), and that many of them showed the type in full perfection, such as no model could excel or equal.

With every descending inch through the mud their size increased; the "grit" soon became "sand;" in a few inches farther crystals were very manifest to the eye, and shortly a "layer" was reached. It is true that in some places no "layers" occurred, the crystals being scattered at random through the mud. But in most instances when from twenty-four to thirty inches of surface mud had been removed, and the crystals had attained a length of one fourth to one half an inch, one or more "layers" would be found within the four feet square of the coffer dam. In these "layers" the crystals were so closely packed as to have no mud intermingled with them; they were nearly as clean as though recently washed in clear water, lying closely stowed and loose, like pebbles on a beach. A "layer" might be one to four inches thick and two feet, more or less, in length, surrounded on all sides by mud which held only scattered crystals, without any such richness as its developed pocket.

Going deeper, the crystals became constantly larger, though less numerous, as the mud grew more dense, until a stratum was reached which was designated "blue clay." In the mud immediately above the blue clay, crystals from one to two inches long were very common, though many of the smaller ones were still intermingled. Here a change in the crystals showed itself, full as well marked as the change in the bed in which they lay. The small crystals were not present; they had never been formed as in the mud above. Instead of them lay imbedded scattered crystals, few in number, but of great size, and having commonly a family look by which they could be recognized. Few of them were as small as two inches in length, and not unfrequently those weighing a pound each were obtained, being perhaps five to seven inches long, by two to four inches wide.

They lay imbedded in the clay, which was so firm that they could be picked out singly, each leaving the sharp mold which it had formed during its slow process of crystallization. They were all within a little more than a foot of the surface of the blue clay, many explorations showing that it was useless to seek for them at a greater depth.

Of the abundance of the crystals within the portion of the lake occupied by them, a space of about forty acres, some idea may be formed from the fact that nine hundred pounds have been gathered from one dam, four feet square. And this by no means represents their full amount, as all the smaller crystals were washed back again into the lake in the process of their separation. At the same time it was remarkably true that the yield was very uneven. In what was known as "rich ground" barren spots constantly occurred, and often almost the entire yield of a dam came from one side or one corner, perhaps only a third or a fourth part of the full area.

The crystals thus obtained had a decidedly green color. The figure introduced is given for the purpose of conveying an idea of the size which the green crystals sometimes attained. It is not an exaggeration. I have seen many which weighed individually as much as the one here delineated. Their proportions were very erratic, but always conforming to the one type.

They were entirely free from the tenacious coating incident to the tincal of other localities; were readily and perfectly soluble in hot water, and in the process of refining by solution and recrystallization yielded their full weight of transparent borax of the finest quality, less merely the weight of the mud which had been mechanically entangled with them during their growth in a muddy menstrum. The green color disappeared in the refining, not being found either in the deposited mud or the new crystals.

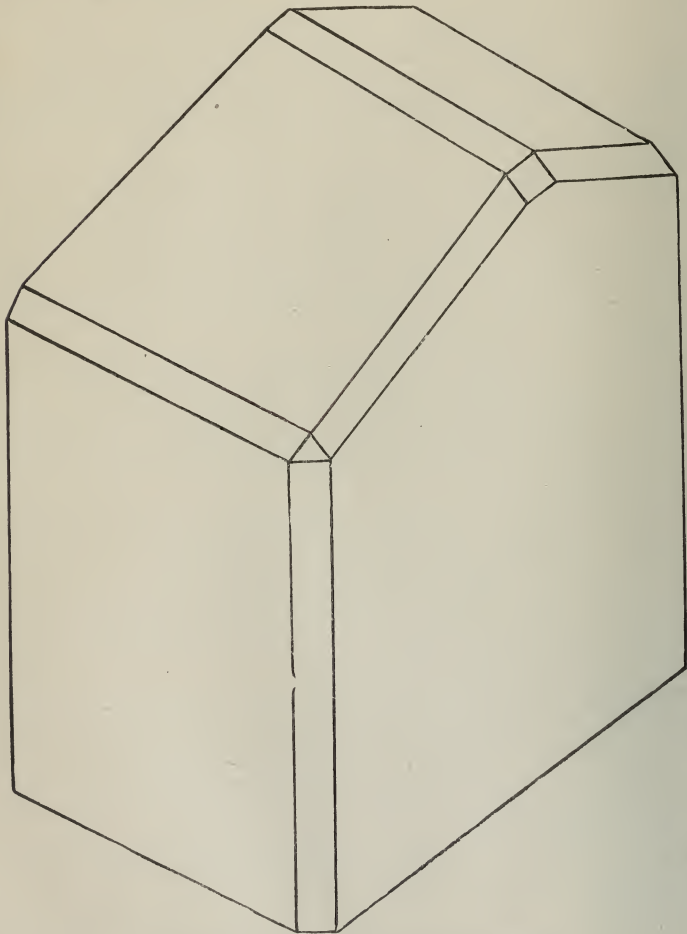


Fig. 7.—Crystal of Native Borax from Borax Lake. . Natural size.

We are prepared now to look at the origin of these salts as held in solution or in crystalline form. If, in a basin of water, more or less shallow, containing a plastic soda-mud in the form



of chloride and carbonate, deriving its carbonic acid from one source and its chlorine from another during its deposition, or, subsequently, fissures were opened in the subjacent strata, allowing the escape of a limited amount of jets of boracic acid from beneath in vapor, we should have all the conditions required to account for the formation of the borax in the midst of the two more loosely combined salts.

Thus far our way is plain. But whence came the enormous deposition of the green crystals of Borax Lake, their isolation and segregation in perfect crystallized integrity, and their continued preservation; while at the same time, in a solution almost identical in chemical composition, as we shall see, at Hachinham, and in which often the proportion of borax to a given quantity of water becomes greater, no such crystals exist?

In most instances of salts crystallizing from a solution, the crystals attach themselves by a base to whatever material is adjacent, and when numerous they form a crystalline mass, from which the summits only of the crystals project—a crystal perfect at both extremities and sides not being common. And in Borax Lake itself, whenever the water has evaporated to such a degree in a dry season as to form a deposit from excess of strength, it has been an amorphous crust of carbonate, chloride, and borate, with no perfect crystals of either.

But the green crystals are isolated, and in thousands of instances are absolutely perfect, ends and sides. The large ones of the blue clay lie, as we have seen, each in its own mold. The smaller ones above lie often in layers, inches in thickness, hundreds of crystals heaped together as distinct from each other and as separate as pebbles on a beach.

Still, again, comes the strange fact that these crystals have been lying, how long we cannot say, but almost certainly for very, very many years (for there is not the slightest evidence to lead us to believe that they are of recent formation), in a solution which makes no approach to saturation, and to whose influence as a solvent they seem totally indifferent.

The water of Borax Lake, when it has a depth in its main extent of five feet, which it often has for very many months, and perhaps years in succession, holds in solution about half an ounce of borax to the gallon. During this interval, for four or five months of the Summer season, its temperature is at no time lower than 55° to 60° Fahr. But water at that temperature dissolves a little over eight ounces of borax to the gallon. How, then, can the green crystals remain in such a liquid so long without being destroyed?

It may be supposed that the carbonate and chloride, in the complex mixture, render the hold of the borax so slight that, because of their presence, it is ready to separate. In reply to this suggestion comes the statement of the fact that when the same water is concentrated by evaporation to a specific gravity of 12° Beaumé, in which state it holds in solution six ounces of borax to the gallon, no tendency is manifest to the formation of even a single crystal.

Again, it has been suggested that, lying in a muddy menstrum, the movement of particles is so far arrested as to prevent diffusion, the stratum of water immediately surrounding each crystal becoming saturated and remaining unchanged. But this does not in the least account for the commencement of crystallization, which so far as we can judge, must have been in an exceedingly weak solution. Nor does it perhaps seem possible that such complete seclusion from ascending and descending currents could in any way be secured. The Winter rains pour in quite fierce torrents of drainage water from all sides, often rendering the entire lake decidedly turbid, and of course causing more or less of commotion in every part. And in addition to this is the diffusion of particles, caused by the changes of temperature throughout the year.

In whatever light, therefore, the question is viewed, it is not free from difficulties. And yet at the same time it is but right to recall the fact that these green crystals are in their nature tincal, though such tincal as has never been found elsewhere, and that the crystals of tincal are perhaps in other localities formed subject to the same conditions as here prevail.

We turn now to Hachinham, the other locality mentioned. This is on the southern side of Clear Lake, about four miles west of Borax Lake, which it closely resembles in its features, though much smaller, being an oval lagoon about four hundred yards in length. We have, as there, a sheet of clear alkaline water, with a bottom of soft, plastic mud. This mud has been bored to about the same depth as in the explorations at Borax Lake, without its lower limit being reached.

The evidences that the alkaline pool occupies the space of an extinct crater, are more manifest here than at Borax Lake, as the inclosing walls still remain, though abraded on their northern extremity, while on the south they rise abruptly to the great mountain summit of Conoktai.

The water of Hachinham holds in solution the salts of soda in the following proportions:

Sodium carbonate-----	75.4
Sodium chloride-----	08.3
Sodium biborate-----	16.3
Total-----	100.0

The mud throughout its entire depth is richly stored with the same salts, but without any development whatever of crystallization of any kind.

After the cessation of work at Borax Lake, in 1868, attention was turned to the resources of Hachinham. Of course, the style of working must be totally different, for here was no borax ready formed, no green crystals needing simply solution and recrystallization. All that was available was a sheet of water, holding the salts above recorded. The problem, then, was to separate in purity the borax—the only one of sufficient value to be worth the effort—and leave the others.

Borax being the least soluble of the three salts, and at the same time much more soluble in hot water than in cold, it was argued that, were the water of Hachinham sufficiently concentrated by boiling and then allowed to cool slowly, the borax would crystallize out, leaving the carbonate and chloride in solution.

This is correct in theory, and in laboratory practice the results were entirely satisfactory, but in working large quantities the case was found very different. Concentrated to 20° B., a crop of crystals was deposited which were pure borax, but they were scarcely more than fifty per cent of the borax originally held by the lye thus formed. When, now, this mother liquor was still further concentrated, no more pure borax separated, but a combined mass of borate and carbonate.

And here was manifested another feature. The amount of borax available depended very largely on the bulk of the solution in which it was allowed to cool. Very small quantities were of course useless in practical working, though the crop from them was satisfactory. Patiently continued trials showed that pans of two or three gallons gave, economically, the best results. But even here the borax clung so closely to the carbonate as to occasion much difficulty, until the plan was devised of crystallizing them together, and then washing away the carbonate by means of its greater solubility.

This was the plan adopted, and by its use about eighty per cent of the borax originally contained in the Hachinham water, as pumped into the evaporating pans, was secured. The extent of the works may be estimated from the fact that about 4,000 of the pans mentioned were in daily use.

But the unassisted lake water was not long used. Hachinham, from its shallowness, becomes nearly or quite dry at the close of each Summer. As it dries away, the exposed mud is thickly covered with the salts deposited. These were carefully removed for use. The surface thus cleared of its salts began at once to renew its coating, the deposit being speedily replaced by capillary attraction from the stores beneath. In a week, or perhaps more, the surface was ready for sweeping again. The second crop was abundant, it was replaced by a third, and by others in succession, till the advent of the rains (never occurring in that climate till October, or perhaps November) put a stop to their formation.

This process was repeated each year during the occupation of Hachinham, and, when the lake filled in turn with the Winter rains, the alkaline water bore the same degree of strength consecutively, showing that the stores of supply in the mud beneath gave no evidence of exhaustion.

The salts thus gathered were used by lixiviation to strengthen the lake water in the evaporating pans, and thus increase the yield of borax.

The work of refining the borax thus obtained differed in nothing from that employed with the green crystals of Borax Lake—hot solution and crystallization in lead-lined tanks. Hachinham borax, as placed in the market, was of a grade of excellence never surpassed.

The works were conducted in this manner until the Spring of 1872, when a change was introduced in consequence of the discovery that immense deposits of borates existed in Nevada. It was determined to utilize the borate of lime, in the form of ulexite, for the conversion into borax of the carbonate of soda held in the water of Hachinham.

The ulexite was brought by carloads from the deserts east of the Sierra Nevada to San Francisco, and thence to Clear Lake, and a great increase in the borax yield of Hachinham was the result. The process adopted was to saturate, with the ulexite, the boiling lye from the lixiviating tanks, before it had acquired sufficient strength to crystallize on cooling. A double decomposition was thus accomplished, resulting in a thick, milky-looking mixture which was an intensified solution of borax, rendered turbid by the insoluble carbonate of lime, this latter speedily settling and leaving the clear borax liquor for concentration and crystallization.

Practically, however, this solution was never pure, for here came in again the same fact which had been demonstrated in the first workings at Hachinham, that the bulk of the liquid in which the action took place had much to do with the chemical union accomplished. In laboratory experiments the work was perfect, and a boiling heat of only a few minutes formed the full theoretical amount of borax demanded; yet, when dealing with large quantities, this proved impracticable. Although violent boiling was long continued, even for hours, analysis of the lye showed that a certain proportion of the carbonate of soda still remained untouched by the boracic acid, and that, too, when the ulexite employed was in excess of the amount which careful analysis showed was sufficient to saturate the carbonate of soda present. And this excess was a necessity, and the daily working came to recognize it and to act accordingly, for, when the even theoretical quantity only was used, a much larger portion of soda remained untouched.

The operations at Hachinham continued vigorously till 1874, by which time the enormous supply of borax brought into the market from Nevada had reduced the price to so low a point that further production became impossible. Hachinham supplied all the American borax made from the cessation of work at Borax Lake in 1868 till 1873, and the two localities afforded, between 1864 and 1874, all that was ever made in California. The yield of Hachinham, during the last two years of its running, was something over five thousand cases of one hundred and twelve pounds each. \* \* \*

These lakes now lie idle for the reason before stated, namely, over production and a glutted market, and to an unfortunate mistake which was made in 1868, when the volume of water was largely

increased by the flow of an artesian well, sunk for experimental purposes, which could not be controlled. This made it unprofitable to evaporate the waters of the lake, and crystals were partly, if not wholly redissolved. This property will keep, and the day will probably come, when with cheaper labor and more favorable conditions, it will again yield its valuable products to the world. The waters will then, probably, be concentrated by the graduation process so extensively employed in the manufacture of salt from dilute solutions. In November, 1866, J. Arthur Phillips, of London, made a report to the company, in which he estimates the borax in the lake at twenty-seven thousand one hundred and twenty tons. These figures are based somewhat on conjecture, and may be in excess of reality; but Professor Phillips is not a man to be easily misled, or to any great extent mistaken. The calculation was made as stated in the following quotation from the above mentioned report:

The total extent of the muddy deposit considerably exceeds three hundred acres, and if we assume that, of this area, only one hundred acres, or that portion now worked for borax crystals, is alone sufficiently rich to pay the expenses of treatment, we shall arrive at the following figures:

One hundred acres are equivalent to 484,000 square yards, and if the mud be worked to the depth of only three and one half feet, this represents about 565,000 cubic yards; or, allowing a cubic yard to weigh a ton of 2,240 pounds, which is a very low estimate, the total weight of one hundred acres of mud, in its wet state, will be 565,000 tons. If we now assume that the mud extracted from the lake contains sixty per cent of water, this will correspond to 226,000 tons of dry mud, containing, according to the mean of the analyses of Professor Oxland and Mr. Moore, 18.29 per cent of borax; but if, in practice, only twelve per cent of borax be obtained, this will represent 27,120 tons of crystallized salt.

If the estimates of Prof. Phillips seem large, what must be thought of the calculations of the company, who assume the available borax on the property to be 684,800 tons, or more than twenty-seven times the entire yield of the Pacific Coast since the discovery of borax in 1856. The estimate of Prof. Phillips is based on the assay of a single sample of the average mud taken from an artesian well at the depth of sixty feet, and the additional amount outside the central 100 acres, also on the result of a single assay of mud. The grand total is made up as below copied from the report of the company published in San Francisco in 1866. It might be considered out of place were I to express my opinion of such estimates, and specially so as I have never made a personal examination of the locality.

It is one thing to calculate the quantity present upon such shallow data, but quite another to prove the estimate correct. There can be no doubt, however, as to there being a large quantity of workable borax in these lakes, which will in future be extracted to the advantage of the owners and the State.

#### ESTIMATES BY THE COMPANY.

In the central 100 acres, above the level of five and one half feet.....	107,800 tons.
In the outer 200 acres, above the same level.....	119,600 tons.
In the central 100 acres, below five and one half feet.....	228,600 tons.
In the outer 200 acres, below five and one half feet.....	228,800 tons.
An aggregate of prismatic borax of.....	684,800 tons.

Now, it must not be forgotten that each analysis was of mud taken from many different points in the lake, and not from one point only, nor from the central 100 acres of ground *previously worked over* by the company; that the mean of these analyses, calculated for anhydrous mud=22.86 per cent, but estimated at *eighteen per cent* only. For the outer 200 acres gave 12.85 per cent, but estimated at *ten per cent* only—and these calculations are based on the supposition that the deposit *near the shore* represents the average richness of the whole,

which we know to be otherwise, for that taken from within 300 feet of the shore gave 32.63 per cent, instead of *ten per cent*; the mean of the two gives 22.74 per cent, and, estimated at these figures, would have given 260,000 tons, instead of 119,600. So that, had we taken as the basis of our estimates the *full value* of the analyses and other tests, we should have had an aggregate of 964,600 tons of borax, instead of 684,800 tons. In these estimates, no account has been taken of the large amount of borax held in solution in the water of the lake, nor of the 200 acres, or more, extending to the eastward, and once forming a part of the lake itself.

Such exaggerated statements reappear in statistical works and reports to the discredit of the State, as, for example, in the fourth volume of the United States Reports of the International Exhibition at Philadelphia, folio 176, it will be found stated that the earth in and around the well known borax lake of California yields from twenty to forty per cent of this salt, "and the material exposed to view is estimated to contain *ten millions of tons of borax*."

The borax produced at the California borax lakes was remarkably pure, and free from those vexatious substances mentioned elsewhere, which interfere with the crystallization. The following analysis is given to verify this statement. I have, also, had considerable personal experience with the products of these lakes at the time they were being worked:

ANALYSIS OF CALIFORNIA REFINED BORAX, FROM SAMPLES FORWARDED BY THAYER AND WAKELEE, OF SAN FRANCISCO, TO HENRY KENDAL AND SONS, LONDON.

ANALYTICAL LABORATORY, SURGEON'S HALL, }  
EDINBURGH, October 4, 1865. }

*Refined Borax.*

Biborate of soda, pure and dry	54.39
Water of crystallization	45.55
Insoluble matter	traces
Sulphate of soda, dry	0.06
Chloride of sodium	traces
	100.00

The above refined borax is of first class quality, and is commercially pure.

There are a number of other localities in California at which borax is being produced at the present time. San Bernardino and Inyo Counties are rich in this mineral. A number of extensive fields are known.

In 1874, one hundred and fifty quarter sections of borax lands were entered in the United States Land Office at Independence, Inyo County, California. Many of them were soon abandoned, as they were not found rich enough to work with profit.

The property of the San Bernardino Borax Mining Company is the most extensively worked, and has already yielded largely. This property lies in township 30 south, range 38 east, Mount Diablo base and meridian. It is in San Bernardino County, near the line of Inyo. The discovery was made February 14, 1873, by Dennis Searles and E. M. Skillings. In April, 1874, J. W. Searles and J. D. Creigh, as company representatives, made application to the same Land Office for four United States patents covering 160 acres of the borax lands. The company was not incorporated until January 1, 1878.

There are three modes of obtaining borax at this locality: the first by evaporating water charged with borax; second, by lixiviation of crude material, mostly sand; and by working quite extensive deposits of tincal.

Crude borax is found on the surface mixed with sand in a light granular form. No ulexite has been observed at this locality. Expe-



rience has shown that it requires thirteen tons of crude material to produce one ton of borax. This is equal to 7.69 per cent. Tincal in a very pure state in crystalline masses is found under the surface of the ground at the depth of from three inches to a foot, mixed with salt and thenardite, so pure that it is called ice, which it certainly resembles. The deposit is not regular, but is described as being "spotted."

The production of borax commenced in 1874. The product readily brings one cent per pound more in the market than Nevada borax. There are no difficulties in the crystallization, and it is equal in excellence to the best borax of Lake County.

The excessive heat and dryness of the climate cause the crystals to part with a portion of water. In Summer 100 parts are equivalent to 105 parts of theoretical borax when they reach London. The borax is hauled in wagons to Mohave station, over a dreary and sterile sandy desert, so devoid of water that a supply must be hauled in other wagons to supply the animals and men with drink. The time consumed in the trip and return is ten days.

The borax is obtained from the crude material in the following manner: There are five steam boiling tanks, each with a capacity of 7,000 gallons; the impure, natural borax is shoveled into the boiling tanks, and the soluble matter dissolved by heat communicated through a wet steam coil, of one and a quarter inch iron pipe. The boiling tanks are made of three-inch Oregon cedar, seven feet deep, and ten and a half feet square on the bottom. They are not lined. When the solutions are brought to the proper strength (16° to 30° Beaumé, according to the character of the material), they are drawn off, while still hot, into crystallizing vats lined with galvanized iron. There are thirty of these vats, which are cylindrical. The borax taken from the crystallizers, after the first operation, is called "*concentrated*," and is not wholly pure. While the solutions are cooling, the mud is sluiced out of the boiling tanks, after which they are again filled, and the operation goes on continuously.

In due time the crystals are taken from the crystallizers and returned to the boiling tanks, a portion of which are kept for this special work. Clean water is pumped in and the steam turned on. When solution is effected, and the liquor has the density of 18°, the liquors are run into square crystallizers, which are also lined with galvanized iron, and the solution made to cool slowly, although the climate is so warm that outside protection is unnecessary. Every precaution is observed that there may be no disturbance during crystallization. The result is "*refined borax*" of a very superior quality.

The mother liquors are returned to the boiling tanks, and used again and again for the first solutions, until they become so foul as to yield crystals of foreign salts, when they are allowed to go to waste. Of the square crystallizers there are nine, six of which are forty-eight feet long, and three, thirty feet long. All of them are four feet deep and four and a half feet wide.

All liquors are returned to the boiling tanks by a steam syphon pump. Water is brought seven and a half miles in inch and a quarter iron pipes for the steam boilers and for drinking; but water for the solutions is derived from fourteen wells, each of which is fifty-five feet deep. These wells are artesian, the water rising three feet above the surface. The entire steam power is derived from one steam boiler, 42 inches in diameter, with 32 flues. Covers to the boiling



tanks are made of Oregon pine. There is a rough wooden building over the boiling tanks, but none over any other of the works. The solutions are drawn off by means of an iron pipe, which passes up through the bottom of the tank, and is connected with a shorter length, to which it is joined by a common elbow, loose enough to turn easily. The jointed pipe is lowered gradually at the proper time, drawing the hot solution from the surface. This is a simple and convenient appliance, the use of which greatly facilitates the operation. It is very much like one to be described in the mention of Teel's Marsh works in Nevada.

A large evaporating trough of wood has lately been added to the plant, which is lined with galvanized iron, and is used in connection with open cuts or trenches in the ground, to concentrate by the sun's heat the foul mother liquors. This trough or tank has a capacity of 10,000 gallons. In it the last portion of borax crystallizes out.

Fifty men and thirty-five animals are employed at these works. All the fuel is obtained from the marsh, being wholly sage brush and grease wood, which grow near by in great abundance. This fuel is gathered in wagons and thrown into the furnace under the boiler with pitchforks. In this work fourteen mules are continually employed.

The lake bed from which the borax is obtained has an area twelve miles long by eight miles wide. An English company, under the management of Mr. T. Dodge, commenced operations near the same locality in May, 1876.

Borates have been found elsewhere in San Bernardino County, although but little is known as to their extent and character. The following newspaper notices are given, as containing about all that is known regarding the new discoveries:

#### BORAX MARSHES.

[Calico Print.]

Besides the large borax fields owned by the Searles Brothers and William T. Coleman & Co., in Death Valley, there are also other localities in this county that have been taken up by other parties. About eight miles southeast of Hawley's Station, at Coyote Holes, there is a marsh of two or three hundred acres surrounded with an immense deposit of borax. The marsh is chiefly a large deposit of carbonate of soda. The borax is of a fine quality, and known as cotton-ball borax. It is necessary, in order to reduce it to a crystallized form, to mix with it carbonate of soda, which nature has, it seems, placed there for that purpose. The best part of this marsh has been located by William Curry, E. J. Miller, and O. H. Baker. The property has been bonded by the James Brothers for \$12,000. Borax is worth thirteen cents a pound in San Francisco, and it is not very expensive to reduce the borax, so that the parties interested are likely to make some money out of the enterprise. Daggett Station is the nearest shipping point, which, fortunately, is not as far from this borax deposit as it is from others.

#### BORAX PATCH.

[San Bernardino Times.]

A 1,200-acre borax patch has been located near Black's ranch, on the line of the Southern Pacific Railroad to the north of us, by a number of prominent gentlemen. The borax is said to be found there from three inches to two feet in thickness, and in almost unlimited quantities. This industry promises to be one of more than ordinary importance to our county.

Mr. S. Heydenfeldt, Jr., lately made a visit to Calico District on business. He sent a sample of a white chalky substance to the State Mining Bureau, for examination, which proved to be "priceite," identical with that found at the original locality of that mineral at Chetco, Curry County, Oregon, and described elsewhere. Soon after

the Calico Print published the following notice, which is at present the extent of our knowledge on the subject. The specimens may be seen in the State Museum:

#### BORAX MINES.

There is considerable excitement in Calico District over recent discoveries of borax deposits within a couple of miles of the town of Calico. The principal deposits are in the eastern part of the district and comprise an area of four or five miles square. Several sales were made last week of borax claims, amounting to \$4,250, and since then, lands hitherto supposed to be worthless have been located in twenty acre claims as borax deposits. Several claims located for silver, but considered poor, have been prospected for borax, and in some places with favorable results. It is claimed by some that there are large deposits of borax in the district, some of it of fine quality. In one place there is a small mountain of it; and if all the deposits located are in reality borax of a marketable quality, the immense quantity of it cannot fail to be a source of great wealth to this district.

Mr. Robertson, one of the firm of Wm. T. Coleman & Co., has purchased the borax deposits mentioned above, and will soon set men to work on the property.

#### KERN COUNTY.

Borate of lime (ulexite) was discovered at Desert Springs, called also Cane Springs, in Kern County, February 15, 1873, from whence considerable quantity has been extracted. The dry lake in which the borates are found is situated in T. 30 south, R. 38 east, Mt. Diablo base and meridian. The following is an extract from the Los Angeles Express, published about the time of the discovery:

#### THE BORAX DISCOVERY IN KERN COUNTY.

As already noted in the Express a very extensive borate deposit has been discovered in Kern County, at a distance of about 120 miles from this city. Specimens of the borate have been on exhibition in this office, and are seen to be of a pure and valuable quality.

The deposits discovered by H. J. Lent lie about 120 miles from this city, about three miles off the Owens River road, near Harry Ball's station, at Desert Springs. They were found about four weeks ago. They extend from Ball's house to the end of the marsh, about nine miles long and three wide. The borate is found in spots of two, three, or four acres, more or less. Messrs. Lent, Ball & Chapman's claims contain probably 500,000 tons of borate of lime; of course, they are the best deposits that could be found at the time. Mr. Lent, however, has no doubt that other deposits, equally valuable, though not so great in extent, will be taken up.

Mr. Lent has been in charge of the borax works at Columbus, Nevada, which, with those at Fish Lake, in the same locality, are the only borax deposits hitherto known on this coast, excepting those of Lake County. He thinks that these new discoveries contain a much larger percentage of boracic acid than the deposits at Columbus. He believes that there is room for the employment of a thousand men in these fields and those at Slate Range, sixty miles distant. He has refined some of the borate, and has made an excellent quality of borax, a specimen of which we have. He is having made at Harper & Dalton's some vats and other rude contrivances for the reduction of the borate, which he intends to put upon the ground, and, after reducing the borate there, ship borax to this city, for transshipment. He also thinks of putting up works there for refining, though he believes it would perhaps be cheaper and better to have a refinery here.

We learn that borate deposits have also been found at Slate Range, about sixty miles distant from the original discovery. A considerable number of locators are moving to the borax fields from Inyo and Kern Counties, and several parties have gone from Los Angeles County. Messrs. Austin and Baker, of this city, are by this time upon the ground, and will undoubtedly secure valuable locations.

#### INYO COUNTY.

Borax was discovered in Death Valley, Inyo County, in 1873, but owing to climatic peculiarities of the region, distance from railroad communication, pre-occupation, and over-production at other more accessible localities, no active operations were attempted until the present year.

Relocation was stimulated by the near approach of the Carson and Colorado Railroad, which is now finished to San Carlos, on Owens

River, will soon be extended to the Colorado River, and will pass within a few miles of the borax deposits, although the final route is still uncertain.

Death Valley, in which these deposits lie, is one of the most remarkable geographical localities on the face of the earth. The following is compiled from notes furnished by Dr. S. G. George, who visited the valley in 1860, William T. Henderson, 1860, Hugh McCormack, 1861, R. R. Hawkins, 1882, I. Daunet, 1883, and others. The subject is one of such peculiar interest that somewhat lengthy descriptions will not be deemed irrelevant.

#### DEATH VALLEY

Takes its name from the circumstance of a company of emigrants entering it on their way from Salt Lake to California in the year 1850. Very little was known then of the passes through the mountains, and this party made the fatal mistake of attempting a more direct pass than the well known emigrant road. They little knew the dreadful experience they were destined to make, or the sufferings they were to endure. The valley was to them a *cul de sac*, a region wholly unexplored. While seeking an outlet, they experienced dangers and difficulties wholly unexpected, and almost insurmountable. Finding it impossible to take their wagons over the mountains, they abandoned them, and while some of the party climbed the rugged and roadless passes, others, seeking water, miserably perished. Those who escaped, in relating the horrors of the journey, told romantic stories of mines, of gold and silver, all generally exaggerated, but which have induced others to visit the locality in search of the mythical mines described. Bennett, one of the emigrants, drank at a running stream of clear water, on the pebbly bottom of which he said he saw lumps of glittering gold; an unlikely story, for gold is seldom if ever seen under such circumstances. Another said he found a piece of white metal which he took with him, not knowing its nature or value until months after, while at Los Angeles, he required a new gun-sight, and delivering the metal to the gunsmith with an order, was informed that it was pure silver.

This story, more absurd, if possible, than the first, has caused a number of parties to visit and explore Death Valley in search of the "gunsight lead," which has never been found. While these expeditions have generally ended in disappointment, they have led to a knowledge of the country, the discovery of mines of antimony, silver, and gold, of unknown value, and now of not less important borax fields. The discovery of Coso, Slate Range, Owen's Valley, Panamint, Argus, Telescope, Calico, and other mining districts, are the results of these expeditions, as will be seen by the notes of prospectors quoted in this paper.

Death Valley proper lies within the area bounded by the meridians  $116^{\circ} 30'$  and  $117^{\circ}$  west longitude, and parallels  $35^{\circ} 45'$  and  $36^{\circ} 30'$  north latitude. Its direction is nearly north and south, length from Furnace Creek south, 40 miles; average width, 8 miles. At the south end, branch valleys extend southeastwardly and southwestwardly; the former is known as "Amargosa Valley," "Bed of Amargosa River," or "Amargosa Wash." It extends 25 miles or more. The latter is "Long Valley," extending 12 miles, and ending in a cañon.

One portion of Death Valley sinks below the level of the sea. The

line of greatest depression lies along the eastern side of the valley, and extends about 15 miles, north and south. The lowest sink is a little east of south from Furnace Creek, and distant 19 miles. It is 110 feet below the sea level. It lies 5 miles eastwardly from Bennett's Wells, and 4 miles due east from the Eagle Borax Mining Company's ground, which is itself 69 feet below the surface level of the ocean. Telescope Peak, only 15 miles west, rises 10,937 feet above sea level, and 11,047 feet above the lowest depression in Death Valley. Its summit is seldom free from snow.

To the eastward rise the Funeral range of mountains, the highest summits of which are 6,754 feet in altitude, and to the west, the Panamint range, of which Telescope is the highest peak. The mountain summits are about 30 miles apart. Beyond the Panamint range lies Panamint Valley, 45 miles long and 10 wide, having a direction nearly parallel with Death Valley, but more elevated; the average altitude being about 1,400 feet. The town of Panamint, in Surprise Cañon, has an altitude of 6,600 feet.

The formation about Death Valley seems, by descriptions given, to be generally stratified, sedimentary rocks, sandstones, and limestones containing fossils. There are in the State Museum, specimens of blue limestone weathered and worn by drifting sands, in which there are undetermined fossil corals.

Very little is known of the geology of this region. The portion below the sea level has but a small area as compared with the immense inclined planes which dip toward it from all directions. If water was abundant, there would be a lake at this point, but the great heat, dry atmosphere, and the loose nature of the soil combine to prevent any accumulation of water.

The Amargosa River heads in Nevada and some of its branches in the Amargosa Mountains. It flows southerly 100 miles or more, when sweeping in a great curve around the base or southern ends of the mountain chains, it returns northerly to Death Valley, which is called also "the sink of the Amargosa." While there are channels produced by floods of great extent, and a cañon cut by the river at some former period, never within the knowledge of man has any water been known to flow into Death Valley through the old river bed, known as the Amargosa Wash. At what period these deep channels were cut is unknown.

Mr. McCormack thinks that the sink of the Mohave, at a certain time not very remote, has overflowed and emptied an excess of water into Death Valley. The Mohave River heads in San Bernardino County.

Near Bennett's Wells Mr. McCormack observed a hill of stratified rocks, yellow and blue, in such strong contrast as to suggest the name "*Curious Butte*," and near by he found flexible sandstone—*Itacolumnite*.

Furnace Creek was discovered and named by Dr. French's party in 1860. Its mouth is fifty-six miles due east from the eastern shore of Owen's Great Lake. It was so named from the discovery by the party of ruined lead furnaces, in which the Mormons had extracted lead from galena to make bullets to be used against the United States troops in 1857. Water flows all the year round, the average quantity being one hundred miners' inches. The water is good for drinking, but is always warm. It has been stated that during some seasons the temperature of the water is 120°. The stream flows for



a few miles from the mouth of the cañon, and sinks in the sand, to be seen no more. The altitude at the entrance of the cañon is 2,874 feet. Quite a settlement in the interest of the borax company has sprung up, which has been named *Greenland*. Garden vegetables, melons, alfalfa, and other plants have been successfully cultivated by dint of almost constant irrigation.

The climate of Death Valley is most distressing to the human body. While in Winter it is quite pleasant, in Summer it is almost unbearable. The dryness of the air is so excessive that moisture is withdrawn from the body faster than it can be supplied through the system. From this cause frequent cases of death have occurred when water was plenty, but which could not be drank fast enough to supply the drain caused by the desiccative power of the dry hot air.

The atmosphere presents many peculiar features, among others, causing a feeling of lassitude and weariness and an intense thirst upon very slight exertion. Many of those who have been for a month or more residents of the valley complain of an affection of the eyes, which become sore and weak. A very short walk will cause great thirst, and at times even the raising of the canteen to the mouth seems an exertion. Mr. Hawkins, who furnishes this information, says: "It has been stated that birds, attempting to fly across the valley, drop dead. While the writer cannot verify this by ocular proof, he has picked up, at different times, two little birds, a mile or so from water, whose bodies were still quite warm, having evidently but just dropped dead. But little or no vegetation can be found a short distance from water, excepting sage brush. Near the creeks only grass, willow, and mesquit bushes grow." During the visit of Mr. Hawkins, in May and June, 1882, almost every afternoon a burning wind, fierce and powerful, sprang up, blowing articles of considerable weight some distance, and hurling the coarse, hot sand with such force as to lacerate the face when exposed, the men being frequently obliged to wear veils and goggles.

The heat was severe, the thermometer averaging from 95° to 100° Fahrenheit in the shade; and in July the average was 100° and over, being often above 120° in the shade. The stones and cement became so hot by ten o'clock A. M. that work was suspended until late in the afternoon, and at night the men frequently rolled themselves in thoroughly wet blankets in their endeavors to keep cool.

Each year the bodies of one or more men and their animals have been found, who have perished from want of water or from climatic effects; a few months before Mr. Hawkins' visit the bodies of two men were found who had attempted to cross the valley; they had food and water still remaining. The climate, in this case, was the cause. Still later, the body of a man was found in Furnace Creek Cañon, only a mile from water. Two men have died this Fall from the effects of the heat; in fact, all who live there are obliged to leave every few months to recuperate.

The following from the Inyo Independent, of recent date, is of the same general tenor:

#### DEATH VALLEY.

The country around Death Valley, and lying in the triangle formed by the eastern line of Inyo and the northern line of San Bernardino Counties, is perhaps the least explored region of the United States. The intrepid prospector, though suspecting the presence of great mineral wealth and ever eager to open new districts, hesitates to penetrate its center, for once lost within its embrace, without water, the poise of the mind swerved by fever, phantasy unseating reason, bewildered, he wanders without aim; his blazing eye beholding heaven in the snowy outline



of the distant Sierras, in the flame of the desert he falls to die! Thus, many in these desolate ranges have lain them down in despair, forever, uncoffined and unknown. It is not a rare event for prospectors to find the bleaching skeletons of those who in early years dared these treacherous solitudes. The whitened bones of the dead seem a natural part of these landscapes—dead men lying on the slopes of dead mountains. Such a skeleton was lately discovered in the Coso range, where it had, by the evidence of papers also found, lain undisturbed for ten long years. What a picture for the imagination is that of the dead lying in these solitudes at the blast of the last trumpet starting again to life—alone!

The experience of Mr. I. Daunet has been still more remarkable. On one occasion he was driven to the necessity of killing his animals and drinking their blood as a substitute for water. Two of his party died from the effect of the heat and want of water. He has just returned from the works of the Eagle Borax Company, of which he is President, finding it impossible to endure the heat.

The terrors of Death Valley seem to arise from three causes: the great heat, which is owing to the physical characteristics described; excessive dryness of the atmosphere; and scarcity of water. From the fact that the valley is surrounded by mountains upon which snow lies nearly all the year, and is the sink of two rivers, and from the experience of the explorers quoted, it is fair to assume, that the valley is underlaid by a substratum in which there is plenty of water. By a system of shallow artesian wells, an ample supply could without doubt be obtained, which could be pumped by windmills or would rise in the pipes to an altitude sufficient to cause the water to flow through hose for irrigation. The excessive heat could be modified by putting cloths over the open windows of the houses and keeping them wet with water—a plan adopted in India, where the heat is also very great. Such a plan, with plenty of water, would render life endurable. But Death Valley will scarcely be selected as a desirable place of residence.

It has been shown that water can be found in abundance by sinking wells in almost any part of the valley. Good water was obtained at Greenland at a depth of eighteen feet, and Mr. McCormack found it at McCormack's Wells four feet below the surface.

Dr. George discovered an unmistakable Indian sign. At the mouth of each cañon leading from the valley, in which there is water, he observed a white stone lying on some conspicuous rock, and on looking up the cañon other stones were seen similarly placed, which lead to water if followed. It is useless to look for natural springs elsewhere. Travelers in the desert will do well to look for this sign.

#### HISTORY.

The emigrant party has been mentioned before, and the reputed discovery of rich mines of gold and silver by them.

After the discovery of the Comstock silver mine in 1858, these old forgotten stories were revived, and in the hope of finding valuable mines, exploring parties were organized to thoroughly prospect the country.

In May, 1860, a party of fifteen men, headed by Dr. Darwin French, left Butte County in search for the Gunsight lead, said to have been found by the emigrants.

They journeyed via Visalia, South Fork of Kern River, Walker's Pass, Indian Wells, and Little Owens Lake; thence, eastwardly, to Hot Mud Springs (which will be described hereafter), to Crystal Springs, Granite Springs, Darwin Cañon, and across the head of Panamint

Valley, thence by a rocky pass to a camp in Death Valley, where the emigrants left their wagons, twenty-five miles a little west of north from Furnace Creek. They discovered and named Furnace Creek, as before stated. The party returned by the way they came, without success as to the discovery they hoped to make. They became satisfied that a pass they came through was the same by which Towne and the saved of the emigrant party made their escape, which led them to name it "Towne's Pass." Among the party were Dr. Darwin French, James Hitchens, N. H. Farley, Dr. W. B. Lilley, Captain Robert Bailey, and J. Lilliard. Darwin, and Darwin Cañon, were named after Dr. French.

October 1, 1860, Dr. S. G. George, Dr. W. B. Lilley, T. J. Henderson, Stephen Gregg, — Thayer, and J. R. Bill, organized to search for the Gunsight lead. They followed the same general route of the French party, remained at the Emigrant Camp for some time, prospecting the hills in every direction. At a locality two miles distant from the camp, named "Hunter's Point," they found water by digging a few feet, and twelve miles distant a fine spring of good water. Although ten years had passed, the tracks of men, women, and children were distinctly seen, as fresh as if newly made; the irons of the wagons were where they had been left. The remains of ox-yokes were seen, which had been laid out for use on the following day, with the chains extended on the ground in front of each wagon, showing the number of oxen to each, and traces of the old camp fires were plainly seen. Plenty of ducks, small birds, and jack-rabbits were observed. While prospecting the hills, Dr. George and Mr. Thayer found the bones of white men within 300 yards of a spring of good water, believed to be of the emigrant party. The returning party followed an Indian trail to Hunter's Point, and through a mountain pass to Wild Rose Spring, which they named, and at which they camped for two weeks, while prospecting in Panamint Valley. On Christmas day they discovered a mine of antimony, three miles from Wild Rose, which they named the "Christmas Gift." Near this mine they noticed hieroglyphics on the rocks, of a very interesting character.

In March, 1861, eight or ten Mexican miners arrived at the Amargosa mines and commenced active operations. Soon after the Indians made a raid upon them, taking nearly all their provisions. This had occurred several times in the history of the mines. A mill was afterwards built, but was left in charge of two men after an unsuccessful trial of the ores. The Indians killed the men and burned the mill. These mines lie southeasterly from Death Valley, in township 19 north, range 5 east, San Bernardino meridian. They were discovered in 1856, and relocated in 1863. The veins are narrow, but rich in gold. The lowest estimate by C. A. Luckhardt is from eighteen to twenty dollars per ton, with much ore in sight. The gold is found in pockets, from one of which \$11,000 was taken.

Mr. McCormack describes them as lying in a belt of diorite, twenty to thirty feet thick, within a country rock of micaceous granite. The quartz is chalcedonic and thin. The whole country is covered with an incrustation of salt. There are springs near by, the water of which is as salt as the ocean.

Nine miles from the mines are the Warm Springs or Saratoga Springs. The water is not only warm, but brackish, and forms a small lake of about an acre in area.

In March, 1861, Mr. Hugh McCormack visited Death Valley. He discovered and named McCormack's Wells, which may be found on some of the old maps. Six miles south of these wells he met with a spring which emitted sulphuretted hydrogen gas. Here the old wagons of the emigrants were found. At Mesquit Springs he saw the shallow grave of a person supposed to be one of the emigrants, probably a woman, as a portion of a calico dress was found with the bones, left exposed by the drifting of the desert sands. Some of the relics from the emigrants' camp have been gathered and placed in the State Museum, where they may be seen by those interested. Efforts will be made to obtain others. Bennett, mentioned before, wandered off in search of water. "Bennett's Wells" were named after him. He walked a day and a half, and found water, and he said, plenty of gold. At one time since, while piloting a prospecting party, he brought a blacksmith's outfit. Anvil Cañon, on the west side of the valley, is supposed to have obtained its name from this, or a similar circumstance. Mr. Hawkins went into the valley by the northern route, which he describes as follows:

Taking the overland train from San Francisco in the afternoon, Reno, Nevada, is reached the following morning, where the Virginia road is taken to the Mound House, and we change cars to the Carson and Colorado Narrow Gauge. After a long day's ride through a comparatively uninteresting country, we reach Candelaria, Esmeralda County, at eight in the evening. From thence the stage can be taken to Columbus, thence via Silver Peak to Gold Mountain, which is our last stopping place before cutting loose from civilization. In the present case the writer found it more convenient to take a team from Columbus, and, after laying in a complete camp outfit, two twenty-gallon kegs for water and provisions sufficient for two men for a week, started. From Columbus our route lay due south to Fish Lake Valley, a charmingly well watered section in comparison to the hot arid desert we were soon to encounter. Through this valley we proceeded to "Piper's," and from there easterly over two mountain ranges, on an excellent toll road, to Gold Mountain, arriving there on the night of our fourth day from San Francisco.

Gold Mountain is the "jumping off place," so to speak, before we enter upon what was but a few years since a *terra incognita*, and here we made our final preparations, and filled our kegs with water.

Our first day's trip was laborious in the extreme. We had an exceedingly steep mountain to cross, and owing to our "buckboard" being heavily laden, were obliged to walk to the summit. The course was southeast from Gold Mountain, and our objective point was some springs called "Coyote Holes," about twenty-five miles distant, which we reached late in the afternoon, and there camped. Early next morning we started, and for twelve miles followed a great salt marsh running east and west. Its crust (being the dry season) was hard and smooth, and glistened in the sun like alabaster. A subsequent examination of this marsh revealed the presence of soda and lime; also, of borax, but not in paying quantities.

At the eastern extremity is another spring called "Poison Springs," the water of which we used for cooking breakfast, but could with difficulty prevail upon our animals to partake of, owing to its brackish taste. From Poison Springs we traveled south through heavy sand until we reached Eutes' ranch, at a place called "Oasis Springs." Here we camped over night and filled our kegs with excellent water.

We were now abreast of the Amargosa, or Grapevine Range, one of the eastern barriers to Death Valley, and I examined these mountains with considerable interest. Owing to their inaccessibility, lack of water, and distance from supplies, these mountains have been but little prospected, although I was shown fine specimens of argentiferous galena and copper, and blende ores from them. Along the crest of the range is a heavy cap of compact lava, extending westward some ten miles, terminating in a bold steep overlooking the wide, rocky desert that surrounds Oasis Springs. From here, eastward, to the "Belted Mountains," some thirty miles, this lava extends westward twenty-five miles to the edge of Death Valley; and northward to the distance of about twenty miles the entire country is covered by lava. The principal centers of eruption are indicated by broad, low-angled cones. The Amargosa, or Grapevine Range, shows altered sedimentary rocks, limestone, schists, and quartzite. The strata are greatly disturbed and dislocated, and, so far as the writer examined, only imperfect fossils were found. The Panamint range on the west side of Death Valley appears to be similarly constituted. These ranges are essentially mountains of upheaval, but wherever examined the lavas were present as subsidiary features.

The Oasis Springs are the head of the Amargosa "River," which here is a creek about two feet wide, and which runs down to the desert, a distance of twelve miles, and is then lost in the sand. We journeyed south, following the dry "wash" of the Amargosa, and made a dry camp in the center of the desert. The next day we reached Ash Meadows, where we camped, and on the following morning proceeded southwest, taking a blind trail for some eighteen

miles, when we turned abruptly a point of the Amargosa range, and struck northeast over the pass into Death Valley proper, between the junction of the Funeral and Amargosa ranges. That night we made a dry camp on the west side of the summit, and the next day arrived early at Furnace Creek, the principal place in Death Valley, and one of the very few where running water can be found. The trip was wearisome in the extreme, owing to the heavy sand, large rocks, and the daily blowing of violent sand storms.

It might seem strange that any one endowed with ordinary intelligence should wish to make a home in this barren, desolate region; yet such is the case. The *auri sacra fames* has induced prospectors to enter this death dealing valley and explore it, they being amply rewarded, some three years since, by the discovery of a large and valuable tract of borax near Furnace Creek. This passed, by purchase, into the hands of Wm. T. Coleman and Frank M. Smith, of San Francisco.

Telescope Mountain and district were discovered and named by W. T. Henderson, in April, 1861, from the view he obtained from the summit. The country seemed to be spread out like a map—the Mohave Desert to the south, Death Valley to the east, Panamint to the west, and a vast area of distant mountain tops in every direction. The hot mud springs near Coso District, mentioned in connection with the expedition of Dr. George's party, called also "*Hell's Half-Acre*," are thus described by that gentleman:

There are hundreds of these springs; some in constant motion, boiling and bubbling mud. There is one oblong basin, one hundred and fifty feet long by seventy-five feet wide, filled with clear alum water, which ebbs and flows every few minutes. It gradually rises from four to five feet, and as slowly sinks again. A white rock thrown into the spring can be seen to sink for a minute or more. The ground around about is hot. Half a mile west lie extensive banks of sulphur. From crevices steam issues, and on the rocks sulphur in beautiful crystals sublimed. The general character of the surroundings is similar to the mud volcanoes in the Colorado Desert, San Diego County. Four miles distant are low hills of obsidian, several extinct volcanic craters, and walls of lava and pumice stone, all showing that volcanic agencies were once very active at this locality.

Southeast from Furnace Creek, in Death Valley, a tract of singularly pure borax has been discovered, situated high up on the hills; also, in the southern portion of the valley, borax has been found. One of the greatest difficulties experienced in winning borax in Death Valley is the trouble of bringing in supplies. To each supply wagon an equally large one must follow filled with barrels of water for the animals, and it takes some twenty days to make the trip from San Bernardino. This difficulty will be greatly lessened when the railroad is completed.

Borate of lime in apparently large quantities has lately been found, which adds greatly to the importance of the locality; for when the available borax is exhausted, the borate of lime will be utilized.

The Greenland Salt and Borax Mining Company have located their grounds and settlement at the mouth of Furnace Creek, where that stream leaves the cañon through which it flows. The Eagle Borax Company have located at Bennett's Wells, twenty-two miles south from Furnace Creek, and ninety miles north of Daggett Station.

Borate of lime exists at these localities as ulexite, and also as "*colemanite*" (which is a variety of priceite) in beautiful crystals, and pandermite, which is also an amorphous variety of priceite. These minerals have been fully described elsewhere under the head of the mineralogy of borax.

Messrs. Coleman & Smith have not as yet produced borax in Death Valley, but are engaged in putting up works on a ridge quite elevated, at which point they have sunk artesian wells.

The Eagle Borax Company have 270 acres of borax lands, from which they expect to extract a large quantity of borax. Besides



borax there is an abundance of thenardite and salt with some trona—(*sesqui-carbonate of soda*). At the present time J. M. McDonald, M. Harmon, C. C. Blanch, and I. Daunet form the company.

The works consist of an iron pan twenty-two by five feet and three feet deep. The fuel used is mesquet wood, of which there is an abundant supply for the present. Fires are built under the pan in which the solutions are made. There are twelve one thousand-gallon tanks of No. 16 galvanized sheet iron, circular in form, with wider bottoms, into which the solutions are run to crystallize. The crystals, of which the specimen No. 4669 in the State Museum catalogue is a type, are taken out every ten days. The crude material (No. 4668) dissolves in the pan with water without leaving much residue.

The borax is hauled to Calico Station via Panamint Valley, Willow, and Granite Springs, Black's Ranch, and Grapevine. The production to the present time has been about 260,000 pounds. The borax is of good quality, and has been sold at ten cents per pound by the carload, and for fifteen cents in smaller quantities.

The first shipment was of the crude natural material, thirty-seven tons, which realized eight cents per pound. This company has made the experience that it is next to impossible to manufacture borax during the hottest season, as the solutions will not cool down to a temperature at which crystallization takes place. A recent attempt resulted in failure for this reason. It is now believed that the work can only be conducted during the Winter, but this will not be a greater hardship than results from the extreme cold of eastern Winters, which, in some cases, is an effectual check to certain manufactures.

The Amargosa borax fields are near Resting Springs, also in Inyo County. The exact locality is township 21 north, range 8 east, San Bernardino meridian. The capacity of the works is eighty crystallizing tanks of 2,800 gallons each. This company will no doubt soon begin to produce borax. William T. Coleman & Co. are the agents.

Soon after the discovery of borax in Nevada several refineries were established in San Francisco, but the market price of the manufactured article was continually falling off, caused by the producers in their efforts to take advantage of the market, and selling the crude material to realize at once. This course produced the very effect they sought to avoid. In the meantime, many costly experiments were made, and when the supply ceased, the works were useless for any other purpose. The first price for refining in San Francisco was forty dollars per ton.

The same difficulties which annoyed the early refiners of crude natural borax, have been met with in California from the date of the first discovery of borax in Nevada. The crude borax from Borax Lake only needed solution and crystallization to yield a product as pure as that obtained from Italian boracic acid by the English manufacturer. But the Nevada crude borax will not part with its mechanical impurities by any simple or inexpensive operation.

Pure borax should dissolve in water to a perfectly transparent solution. No natural borax does this. The so called concentrated borax of Nevada becomes milky in solution; some transparent crystals form when the solutions cool, but for the most part they are opaque, and on being again dissolved, the milkiness reappears, technically called by the refiners "the enemy." When filtered the crystals are pure, but if the clear mother liquors are concentrated by evaporation, the enemy again makes its appearance. It is too costly and



inconvenient to filter large hot solutions, and at the present price of borax cannot be afforded.

The secret of refining, therefore, seems to be to get rid of the enemy in the first operation, and by some inexpensive operation. Attempts to solve this problem have cost much money and caused great disappointment, while the results have been only partially successful. Long boiling of the solutions, and standing twelve hours or more in the boiling tank, while kept hot by means of a dry steam coil, has given the best results; but this operation is expensive, both in time and fuel.

I am informed that the New York refiners adopt the following plan: The crude borax is dissolved in a tank of boiler iron of a capacity of 3,000 gallons, around the sides of which a dry steam coil is placed. The contents of the boiler are stirred by machinery. The plan is somewhat that of the separator of a silver mill, and is driven in the same manner, by gear. The steam coil being on the sides, the bottom is clear, and there is nothing to interfere with the action of the mechanical stirring apparatus. When the proper charge is in solution, three or four pounds of common glue are dissolved in three buckets of hot water, and gradually stirred in. Steam enough is passed through the coils during the night to keep the solution hot, and the whole suspended matter falls to the bottom, leaving the solution clear, which is drawn off in the morning, still hot, into the crystallizing vats, which are allowed to cool slowly in the usual manner.

I have tried this on a small scale in the laboratory with good results, but cannot vouch for its success in the large way.

I lately made the following experiment on a sample of crude material from Death Valley, Inyo County: Solution was made and the sand filtered off, the clear liquid was slowly evaporated in a porcelain dish, a precipitate soon began to form, which was filtered off when the solution had attained a specific gravity of 1.020. The solution was again evaporated. Evaporation and filtration were repeated until a pellicle formed, when the dish with its contents was set aside to crystallize; the crystals were clear, and the mother liquor also; the precipitate was the "enemy," and no doubt the *buttermilk, grease, etc.*, of the old refiners. It was analyzed by Mr. Edward Booth, and appears in the second report of the State Mineralogist, folio 12, to which the reader is referred.

Many attempts have been made in California and Nevada to produce borax from borate of lime, but up to the present time with only partial success. As the exhaustion of the deposits of natural borax is only a question of time, and as extensive deposits of the borates of lime have lately been found, this subject is one of great importance to the State.

Ulexite was used at Lake Hachinhama, in Lake County, and with what success may be learned by referring to the paper by Dr. Ayres. Boiling for hours in a solution of carbonate of soda failed to effect a complete decomposition, but the then high prices of borax and other circumstances made the operation, defective as it was, one of profit.

The following experiments were made to test the accuracy of an assertion made by Mr. I. Daunet, to the effect that he had wholly decomposed borate of lime from Death Valley by boiling with natural crude carbonate of soda. The sample was a mixture of *cotton balls, sheet cotton*, and sand. The distinction between these varieties is explained elsewhere.

When mixed with much water and thoroughly agitated, the ulexite (*a*) remained for some time suspended, and was readily drawn off with the water, leaving the sand (*b*) in the vessel. On standing for some time undisturbed, it wholly settled, leaving above it a light amber colored liquid (*c*). The purified ulexite was very retentive of water. When dried over a water bath it was white and silky, but the long fibers were broken; yet under the microscope it was seen to be a felted mass, entirely free from mechanical impurities. This result verified my experiments made in 1871, and described under the head of ulexite. The sand (*b*) was dried and weighed 0.188 per cent. Examined microscopically it was found to be ordinary desert sand. The amber-colored liquid (*c*) was evaporated to dryness, leaving a white residue (*d*) 3 per cent.

During the evaporation a powdery precipitate separated. This was examined microscopically, and found to be in scales like boracic acid. Another portion of the same precipitate was wet with alcohol and inflamed; the flame had a distinct green color, and showed with the spectroscope the characteristic green bands of boracic acid. This reaction was intensified by repeating the experiment with the addition of sulphuric acid. When again treated with water, a portion of the residue (*d*) remained insoluble, but wholly dissolved in nitric acid, without effervescence.

From the liquid (*c*) obtained in larger quantity by a second operation, octahedral and prismatic borax crystallized out. The crystals were perfectly transparent and hard.

A portion of the original substance was treated with alcohol and inflamed. A strong reaction for boracic acid was obtained, both by the eye and by the spectroscope, proving that free boracic acid was present.

The purified ulexite (*a*) was dried on a water bath, and weighed 48.0 per cent. A portion of the original substance was dried on a water bath; the loss was 47.5 per cent (water).

## RESULTS.

<i>a</i> —Dry ulexite.....	48.000
<i>b</i> —Sand.....	0.188
<i>d</i> —Borax and boracic acid.....	3.000
Water.....	47.500
	98.688

One hundred parts of the dry purified ulexite (*a*) was mixed with one hundred parts of Nevada crude carbonate of soda. The mixture was boiled one hour, during which the volume of liquid was maintained by adding water. The insoluble matter became more and more granular and heavy, no longer floating, but settling to the bottom, leaving a clear solution. In pouring this liquid off, the carbonate of lime separated perfectly, which was dried and examined. It weighed 28.00 per cent. Seen under the microscope, it had lost its silky appearance, and had become white and amorphous. It dissolved in dilute hydrochloric acid with violent effervescence, leaving a residue of mud—9.685 per cent. This residue was fine desert sand from the crude soda. The solution was evaporated to crystallization, yielding borax, 31.6 per cent, which is equivalent to 11.56 per cent of boracic acid. By theory the yield of boracic acid should be 49.5 per cent. These results show the loss of boracic acid to be 37.94 per cent in this practical working, which coincides with operations on a large scale, in which loss has always been admitted.

The method of decomposing borate of lime in England, where muriatic acid is a bi-product in the manufacture of soda from common salt, is as follows: The borate of lime is digested with two thirds its weight of common muriatic acid at a boiling heat until it is wholly decomposed; water is then added to restore that lost by evaporation during the operation. The clear solution is decanted from the insoluble part, and allowed to cool; boracic acid crystallizes out, leaving chloride of sodium, chloride of calcium, and the excess of muriatic acid in the mother liquor. The boracic acid is separated and drained, or pressed, to remove excess of water, and dried.

The Elsworth Borax Company of San Francisco treated borate of lime for several months in 1880 and 1881, but as I learn, with only partial success. They worked a ton of ulexite at a charge, which they decomposed by boiling with concentrated solution of Nevada crude carbonate of soda.

Many tons of ulexite were shipped to Liverpool. From 1873 to 1875, two hundred and thirty-seven tons were taken from Rhodes' marsh in Nevada, and the balance from the Mohave deposit at Desert Springs, in Kern County, California. Works were put up at Columbus, where considerable quantities were treated by the Formhals process. The Mohave deposit was afterwards sold for \$5,000.

The following description of the Formhals process is furnished by Mr. H. S. Durden, who has had much practical experience, both in Nevada and California:

#### MANUFACTURE OF BORACIC ACID FROM BORATE OF LIME.

Several attempts have been made, from time to time, to utilize the borate of lime found in several localities in Nevada and Southern California, for the production of boracic acid. None, however, proved successful, until the invention of Mr. Formhals, of San Francisco, to whom occurred the happy idea of using sulphurous acid; rendering the process simple, cheap, and easily applicable in any locality. This process has been successfully applied, on a practical scale, at two establishments in San Francisco. First, in the works of the American Boracic Acid Company, on Main Street, where between four and five tons were produced from borate brought from Kern County; and subsequently at the Borax Refinery at North Beach, from borate of very low grade from the same locality, and some of superior quality from the Columbus District, Nevada; about the same amount being manufactured as in the former instance. From a chemical point of view, this process is a very elegant one.

A quantity of the crude borate is placed in a wooden tank, and mixed with about three times its weight of water. The mass is then heated by the injection of steam to a temperature of 180° to 200° Fahrenheit. Sulphurous acid gas is then forced in, either by an air pump, or a contrivance known as the Archimedean screw, until the decomposition is complete, which is ascertained in the usual way by means of litmus paper. The whole charge is then run off into a settling tank, where the sulphite of lime subsides to the bottom, leaving the boracic acid in solution in the supernatant clear liquid. This, while still hot, is run off into shallow lead-lined crystallizers, and on cooling affords an abundant crop of very pure boracic acid, seldom containing over four per cent of impurities, consisting chiefly of chloride and sulphate of soda. The apparatus is shown in figure 8: (A) Sulphur oven, (B) air pump, (C) decomposing tank, (D) settling tank, (E) crystallizer.

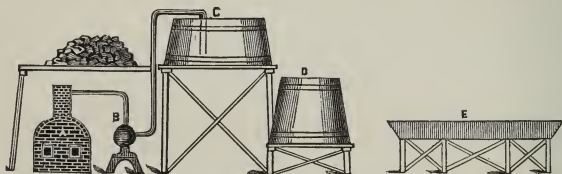


Fig. 8.

Theoretical reactions in Formhals' process:  $(2 \text{ Ca O, Na O, } 5 \text{ BO}_3, 10 \text{ H O}) + (4 \text{ SO}_2) = 2 (\text{Ca O SO}_3) + (\text{Na O SO}_3) + (\text{HS}) + (9 \text{ H O}) + 5 \text{ BO}_3.$

The following is an extract from the San Francisco Mining and Scientific Press of April 7, 1883, relating to a new process for the extraction of boracic acid from ulexite. This process has not as yet been tried on a large scale, to test its practical value:

Wm. B. Robertson, Jr., of this city, has just patented, through the Mining and Scientific Press Patent Agency, a simple and inexpensive means of forming nascent gases directly and upon the spot; and, also, a process for treating the borates with them. The process is such as to avoid expense; and one advantage is that the waste is avoided attending the employment of the sulphuric acid of commerce when poured directly into the borate solution.

The object of the process is twofold, namely: to set free the boracic acid more rapidly and effectively, by the employment of a strong reagent, and to cheapen the cost of operation by providing a means for making this reagent directly and in close connection with the substance to be acted upon, whereby the necessity of two operations, to wit: the separate and expensive manufacture of the sulphuric acid, and its transportation as such to the field of operation, is avoided. The process consists in a means of forming nitrous and sulphurous vapors, and admitting air thereto, and in a means for forcing said vapors into a tank containing a suspension or solution of the borate.

A tank is provided for the solution, and an ordinary furnace is used for containing sulphur to undergo combustion. In this furnace is a pot containing any suitable nitrate. The furnace has a front aperture with a sliding door, so as to admit more or less air. A pipe connects the furnace with the tank, said pipe extending down in the tank nearly to its bottom. A steam boiler is provided, from which is a pipe extending into the other pipe, which connects the furnace and tank so that pressure of steam will act as an injector, and carry the furnace vapors into the borate solution in the tank.

The process is as follows: In the tank is placed water, and the borate introduced. If borate of soda, a solution is formed; if borate of lime, or magnesia, they are held in suspension. In the furnace is placed sulphur, and it is ignited. The pot rests over the sulphur and contains any suitable nitrate—such as nitrate of soda—which is commonly used in the manufacture of sulphuric acid. In order to start and assist the operation, Mr. Robertson places in the pot with the nitrate a small quantity of hydrated sulphuric acid. In this furnace are formed, as is well known, the nascent gases of sulphuric acid, namely, the nitrous and sulphuric vapors, which, together with the air drawn in through the front of the aperture, contrive to produce the result. The steam from the boiler passing through the pipe acts as an injector, and forces or carries with it these vapors through the furnace pipe into the borate solution or suspension in the tank.

The effect of this is that sulphuric acid is formed and introduced directly to the solution. It takes up the soda, lime, magnesia, or whatever may be the base of the borate, and precipitates it as a sulphate. The boracic acid is set free, and the solution may be drawn off, where it crystallizes in a free state in the proper crystallizing pans. The effect of the acid in the borate solution is the same, whether this latter be cold or hot; that is, the reaction takes place, and the boracic acid is liberated, so that at the beginning of the operation, when the solution is cold, the operation is taking place; but before the process is complete the solution warms up under the steam, so that when ready to be drawn off it is hot enough to provide for the proper crystallization of the boracic acid. Thus no time is lost, and the means will conduce to the end. This treatment with sulphuric acid formed directly and in connection with the borate solution, the inventor deems preferable to the treatment with sulphurous acid gas, because he attains a stronger and more effective reagent with a little trouble. The great advantage possessed by the process over that in which the hydrated sulphuric acid of commerce is used is that it is more economical, both in trouble and expense. Of course Mr. Robertson is aware that heretofore borates in solution have been treated with sulphurous acid, and does not broadly claim this, but confines himself to the details described.

The Gutzkow patent process has not, as I believe, had sufficient practical test to prove its value, or otherwise. The following detailed description is quoted entire from the Proceedings of the California Academy of Sciences, April 7, 1873:

#### A NEW PROCESS FOR THE EXTRACTION OF BORACIC ACID.

[By F. GUTZKOW.]

I beg to bring to the notice of the Academy a process for the working of borate of lime, which, besides that I consider it to have some claims as to practicability, presents, also, some scientific points which may be sufficiently interesting to some of the members as to warrant me in drawing their attention thereto.

The Academy has already been made aware of the fact, that in the State of Nevada lately, large masses of borate of lime have been discovered in different places in Churchill, Esmeralda, and other counties. It is interesting, because boracic acid is by no means very profusely distributed on the earth's surface, and borate of lime in particular, has, until now, only been found



near the celebrated nitrate of soda deposits of Iquique, in South America. The mineral found in Nevada is the same as the South American. It is not the true borate of lime, but the boronatrocalcite, a combination of the borate of soda with the borate of lime. An analysis made by myself, gave, in round numbers—

Boracic acid	42
Lime	13
Soda	8
Water	37

100

There appears to be some difference in the impurities found with it. In Nevada they appear to be principally clay, while in South America, gypsum is always, more or less, found intermixed.

Owing to these impurities, there have been experienced some difficulties in working the mineral in England and France; but still more has the expectation that the South American borate of lime would give a prolific source of borax been reduced by the circumstance, that the shipments from Iquique turned out to be of very unequal nature as to quality, which, with the difficulty of ascertaining the true proportion of boracic acid by an easy assay, rather demoralized the market for the substance in question.

In this country, the process used for working it consists in a kind of concentrating operation, by which, with an enormous loss in substance, the borate of lime is freed from impurities. Then it is boiled with a solution of carbonate of soda, and the solutions obtained worked for a crude borax, to be refined afterwards by recrystallization. This process has several important drawbacks. In the first place, the high price of soda on this coast interferes seriously. Although the State of Nevada possesses large deposits of crude soda, it becomes so dear by the high cost of transportation, that in this city it is about as advantageous to employ the English sal-soda, which is, besides, a much purer article. Furthermore, the decomposition of the borate of lime is not complete by soda, and the residue will always contain some undecomposed mineral, unless a very large quantity of water is used. As the borate of lime is not insoluble in water, it is possible to extract by water alone, all traces of the mineral; but on the large scale, this is, of course, not feasible. In the third place, the clay mixed with the mineral, and the carbonate of lime formed by the soda, make the residue extremely bulky. It takes a long time to make it settle into a pulp of some reasonable thickness; therefore several washings are required to wash the absorbed borax solution out, thus yielding weak solutions, which have to be worked up and concentrated.

In view of these facts, I thought it advisable to devise a better process than the one described. My process is based upon the volatilization of boracic acid by water vapors; a fact which nature itself proves, by furnishing in that way all the boracic acid manufactured in Tuscany. But by my own experiments I discovered that volatilization can be made complete; that is, that a given quantity of boracic acid can be completely volatilized by steam alone.

The plainest experiment which laid the foundation to my process is this: To melt in a platinum crucible some boracic acid into a glass, weigh the crucible with contents, and conduct steam by a brass tube into the crucible while the latter is heated to redness. By weighing from time to time the process of volatilization may be observed. After two hours continuing the experiment, more or less, the crucible will be found entirely empty. Other experiments by which I suspended a weighed platinum wire, on to which a pearl of boracic acid was molten, in an iron gas pipe, and conducted steam of different temperature through that apparatus, showed that the speed of the volatilization is entirely depending upon the temperature of the steam. Steam of 212° Fahrenheit is not capable of removing more than traces unless the reaction is allowed to continue for a very long time. If the gas pipe surrounding the boracic acid pearl is, however, heated to redness, the volatilization is most rapid.

The rather surprising fact that the steam of 212° Fahrenheit has so little power for the purpose caused me to experiment on some statements made by Henry Rose, the celebrated chemist to whom we are mostly indebted for our knowledge of the element *Boron* and its combinations. Rose states that it is not possible to concentrate a solution containing free boracic acid without loss of substance. I found this correct when the solution is evaporated in an open dish, but not so when the concentration takes place in a glass flask. On concentrating a quite concentrated solution of boracic acid in a glass flask, over a moderate fire, I never could condense more boracic acid than the mechanical carrying off by the vapors would account for—that is, a trace. In an open dish, however, in the progress of concentration, a ring of boracic acid separated on the dish, which boracic acid is heated much more than the solution, and is exposed to the action of the steam rising from the liquid. In that case a volatilization takes place.

Having found out that superheated steam is much more powerful in carrying off boracic acid than steam of 212° Fah., it was easy to conclude that the condensation of the volatilized boracic acid could not present great difficulties. The boracic acid volatilized in the apparatus described before, that is, in a heated iron pipe. By regulating the length and temperature of the pipe the fact resulted that the steam could be deprived nearly entirely of its percentage in boracic acid.

From these facts the following process of working borate of lime suggested itself:

The borate of lime can be used as found on the borax marshes, or more or less purified if it has to be transported some distance. It is placed in a lead-lined shallow pan, covered with



half the weight of water, and allowed to stand for a day, or longer, in order to allow the lumps to dissolve. Then from one quarter to one half the weight of sulphuric acid is added, and the whole well stirred into a stiff pulp, which is taken out and thrown in a heap. After some days the mass has become hard, as the gypsum commences to set. With this first operation the mass is ready for the second operation—the distilling with steam. It is done in an iron retort with an arrangement for heating it. An ordinary gas pipe, twelve feet by one and a half feet, would answer very well. It ought to stand in an upright position, in order to facilitate the charging and discharging, as also to cause an equal action of the steam. When the pipe is sufficiently heated that no condensation of steam can take place, steam is admitted. It becomes superheated within the retort, and carries along the boracic acid, leaving a porous mass of gypsum, etc., which, when the operation is continued sufficiently long, will be found entirely free from boracic acid. It has been mentioned before that the rapidity of the action depends only on the heat employed. If the temperature of the retort is near the red heat, from one to two hours will suffice to finish the operation in the lower part of the retort. At a temperature only, say 400° Fah., which is very easily reached within the retort, about four hours will be required.

The details of the apparatus which allows a continuous working, and by withdrawing only half the contents every few hours, allows the mass to be exposed twice as long, that is eight hours, to the action of the steam, I will omit here.

The steam which leaves the retort is highly charged with boracic acid. It can be made to absorb not less than the fourth part of its weight of the hydrated boracic acid. From the retort it passes into a brick or lead-lined wooden chamber, where most of the hydrate of boracic acid will deposit. Thence it passes into another chamber, or better, a long flue provided with some metal grating, before it escapes into the atmosphere. Also, a worm condenser can be used, and with it a strong solution of boracic acid will result. It may also pass through a coil of lead or other metal, which utilizes the waste heat. There are numerous devices to remove, by partial condensing, the last traces of boracic acid, if desired.

Most of the boracic acid is, however, found in the first chamber as hydrate,  $\text{BO}_3 + 3\text{HO}$ , and can be from time to time removed. It can be easily melted into a glass, taking care to condense the fumes during melting, and is then absolutely pure. In the state as found in the chamber it may contain a little sulphuric acid, but by admixture of some coke and charcoal with the top layer in the retort, the sulphuric acid can be entirely converted into sulphurous gas, which escapes, uncondensed, from the chambers. There is no other substance present to interfere with the purity of the product obtained. In a mechanical way nothing can go over, as the mass within the retort gets all glazed over by boracic acid.

The advantages of the process are, that with very little labor in one single and short operation, the mineral can be exhausted. There are no rich residues left to be worked over, nor liquor to be concentrated, which makes the lixiviation process so complicated. Besides, the boracic acid, and particularly the boracic acid glass, can bear the high cost of transportation from the borax marshes much better than the borax or the borate of lime. To bring one pound of borax from the marshes to the market, that is New York or European ports, costs now from six to seven cents. To transport the molten boracic acid which gives three pounds of borax nearly, would reduce the cost for one pound of borax by two thirds.

### BORAX IN NEVADA.

What is known as the great basin is a peculiar geographical feature of the Pacific Coast States. It is a depression between ranges of mountains, from which there is no outlet to the watershed. Streams, generally small, which head in the snowy mountains, if they do not sink in the sandy desert soil, or wholly evaporate, give birth to alkaline lakes, of which Mono, Owens, Walker, Carson, and Humboldt are the most important. There are a multitude of lesser "sinks," as they are called, which are subject to great vicissitudes. During a season of unusual rainfall, or a phenomenal winter accumulation of snow on the mountains, great sheets of water are formed in natural depressions on the alkaline plains, which, when the conditions vary, appear as extensive fields of dry, white, efflorescent salts, consisting wholly of soluble matters gathered by the water in its passage from the melting snows, which it left in a state of almost absolute purity. The soil is generally sterile, except in certain valleys, and is largely composed of the debris of volcanic rocks and lavas, rich in soda feldspar, which readily parts with its alkali. Immense flows of a peculiar yellowish semi-crystalline lava have covered the country for many square miles. They seem to have had their origin at or near the circular basin in which Mono Lake lies, and they extend

quite to the base of the great White Mountain range which forms the northern part of the Inyo Mountains.

Owens River cuts through this formation in its passage to the valley, having excavated a cañon hundreds of feet in depth. The same formation crops out at Adobe Meadows, at Benton, Whisky Flat, and elsewhere.

The waters of Mono and Owens Lakes are of the same general character, although more than one hundred miles apart, and they both contain boracic acid in solution. They have other features and peculiarities in common. Both cover nearly the same area. Both are subject to rise and fall, according to season. Both deposit the rock or mineral called "*thinolite*," which forms when the waters become supersaturated. The waters are very heavy. When shaken in a glass bottle they appear like thin oil. When thrown on a flat surface a voluminous white incrustation is left as the water evaporates. At the margin of the lakes a peculiar disagreeable smell is observed like that of an adjacent soap factory. The waters possess great deterative properties. When mixed with oil and shaken in a bottle, an emulsion is formed, which is an imperfect soap, and the oil cannot be made to separate even by long standing. If boiled, the saponification becomes perfect. The specific gravity of a sample of the waters of Mono Lake in the State Museum is 1.038. It acts immediately on animal matter. If placed on the skin, that smoothness caused by caustic potash, well known to chemists, is soon observed.

If to the water hydrochloric acid is added, a brisk effervescence is the result. Boiled in a silver dish to one half, only a small precipitate falls, but the dish becomes blackened from hydrosulphuric acid present. A litre of the water contains 41.8 grains of solid salts, consisting largely of chloride of sodium, sulphate of soda and carbonate of soda, with borax or boracic acid, as before mentioned, in very much smaller proportion, and probably other valuable substances. No complete analysis has yet been made, but samples have been obtained from the most important lakes of the State for that purpose. I have before predicted, and now repeat the opinion, that these lakes will eventually be utilized, and the salts they contain extracted with profit to those who may engage in the business, and to the general advantage of the State.

It is not easy to account for the boracic acid in these waters; the theorist is at a loss to decide from his limited knowledge whether borax, ulexite, priceite, pandermite, etc., are derived from the decomposition of other borax minerals, such as tourmaline, datolite, danburite, and axinite, which may exist in the crystalline rocks in greater quantities than is generally supposed, from volcanic or solfataric agency, like the Italian deposits, boracic acid being given off in steam jets, and combining with the soda of the carbonate known to exist in the waters of these or similar lakes of a former period to form borax, and with soluble lime salts, to produce ulexite, or, if the rivers have brought down soluble borates gathered from the soil which may have derived its boracic acid from the volcanic rocks before mentioned. Whatever theory or theories may be advanced, the fact remains, that fields of borates in very large quantities at some localities, and in spots and patches at others, are known to extend from Oregon to Arizona, and over a vast scope of country.

The history of the discovery of borax and borates in Nevada, which followed that of Borax Lake in California, already mentioned, may be summed up as follows:

The first borax mineral found was ulexite, in the form of cotton balls, as they are called, thus named from the silky felted or interlaced crystals which the globular masses show when broken. They were from the size of peas up to twelve inches in diameter.

In 1860 Dr. Veatch met Mr. William Troop in Virginia City, and told him that he had tested water from Mono Lake, and had seen indications of borax in it, and also in some minerals from the same locality, and thought borax would eventually be found in Nevada.

In 1864 Columbus Marsh was located by Smith & Eaton as a salt bed. Some borate of lime was then found, but no notice was taken of it until a specimen came into the hands of Dr. Partz, then engaged in metallurgical operations at Blind Springs, Mono County, California. He recognized the mineral, but did not attach any special importance to the discovery. Specimens were sent to the Eastern States, which were noticed in Dana's Mineralogy, and found a place in the cabinets of mineralogists.

In the latter part of 1869, a teamster, as he drove along the road to Wadsworth, walking beside his slowly moving wagon, picked up a cotton ball, which he broke open, and noticing and admiring the silky crystals, brought it with him as a curiosity. It found its way eventually to San Francisco, where it came to the notice of certain well known capitalists, who sent out a prospecting party to search for the locality. After a fruitless hunt the party was about to return to San Francisco disappointed, when Mr. W. H. Burgess, an old resident of Nevada, and keeper of the well known Burgess Station, directed them to Virginia Marsh. While they were gone, he discovered the place where the teamster found the cotton ball specimen. On the discovery becoming known, a systematic search for borax commenced, which has continued with intermittent activity to the present day. In 1871, Mr. Troop discovered borax (cotton balls) three miles from Columbus, Esmeralda County. About the same time he found a deposit forty-five miles southeast of Ragtown, near Salt Wells, at which spot he located the property afterwards owned by the American Borax Company. He brought a sample to Ragtown, obtained a wash boiler from Mrs. Kenyon, and carbonate of soda from Ragtown Lake, which he boiled with the cotton balls and water, obtaining the first borax ever made in Nevada. Flushed with the success of the first operation, he brought 1,700 pounds of ulexite from near Columbus, which was made into borax in San Francisco by Mosheimer & Stevenot, at North Beach. The first yield was sold to Isaac S. Van Winkle, iron merchant, of San Francisco.

In April, 1872, Dr. Degroot wrote to the San Francisco Evening Bulletin as follows:

At Sand Springs, fifty miles east of Wadsworth, there is a large area covered with borate of lime, and there are works capable of manufacturing a ton of borax per day running with profit and success. On an alkali flat, twenty miles southwest of Wadsworth, borax salts are found; also, at Hot Springs, nineteen miles northeast of Wadsworth.

A few hundred yards northeast of Ragtown Lake there is a small lake about one and a half miles in circuit, the waters of which are supersaturated with salts, including borax. The lake has no outlet. A few years ago a San Francisco company attempted to work it for borax, by pumping the water and conveying it to an alkaline flat, where it was supposed to evaporate by the sun's heat. The operation was not a success, and was abandoned.

## TEEL MARSH BORAX FIELDS.

Teel Marsh, or Teel's Marsh, Esmeralda County, Nevada, lies about sixteen miles northwest from Columbus, and about the same distance west of Virginia Marsh. As far as I can learn, it takes its name from quantities of ducks which were found there when first discovered. This is, and has been, the most productive borax field yet found on the Pacific Coast. The following account of its discovery is from the Scientific American of October, 1877, and approved by the gentleman named as being substantially correct :

This remarkable discovery was made in Esmeralda County, Nevada, October 12, 1873, by a young man who was prospecting for mines of gold and silver. While thus engaged, wandering over mountains, cañons, and valleys, he discovered in a valley known as Teel's Marsh which appeared (in the distance) to be a vast bed of white sand, resembling dry sea foam. Upon arriving at the place, he found it to be the bed of a dry lagoon, with the appearance of having been dry for centuries. He found the surface to be soft and clayey, often sinking ankle-deep. After an examination of the curious deposit, he put several handfuls into his pockets and returned across the mountains to Columbus, a distance of twenty miles. There an assayer pronounced it the richest sample of crude borax he had ever seen. It soon proved to be an enormous deposit of crude borax, two and one half miles wide and five or six in length. It was more than one man could manage, so a brother was sent for, and the two (now widely known as the Smith Brothers of Nevada) worked with a will, sparing neither time nor money until the whole deposit was their property. They at once obtained boilers, tanks, crystallizers, etc., from Chicago, and began operations. The result is, that in the course of three or four years the brothers have perfected an immense establishment, and are producing an enormous quantity of a chemically pure article of borax, which stands first, and is in demand in every household, to whom it is supplied by grocers and druggists throughout the country.

It will be seen, by referring to the statistics relating to the production of borax on the Pacific Coast, that a large quantity has been obtained at this locality, and there is reason to believe that much more will be extracted.

The method employed by Smith Brothers for the production of borax from the crude material is by solution, separation of mechanical impurities by settling, and crystallization. The result is *concentrated borax*. When this is recrystallized, it is known as *refined borax*. The deposit is known as *crude borax*, specimens of which may be seen in the State Museum, numbered 3380 and 3381. It occurs as a superficial stratum, varying from half an inch to eighteen inches in thickness. This is raked into windrows, shoveled into wagons, and hauled to the borax works, situated on a small hill near by. The heat required for solution is obtained from two twenty-four-inch steam boilers, which are supplied with water by a Cameron & Douglas steam pump. There are nine boiling tanks, of boiler iron, eight feet in diameter and seven feet deep. From the boilers the steam is conducted to the boiling tanks through two-inch iron pipes to a wet coil of a peculiar form—shown in figure 9—a vertical pipe, carrying the steam to the center of the coil (if this is a proper term), which is pierced full of small holes, through which the steam escapes into the solution.



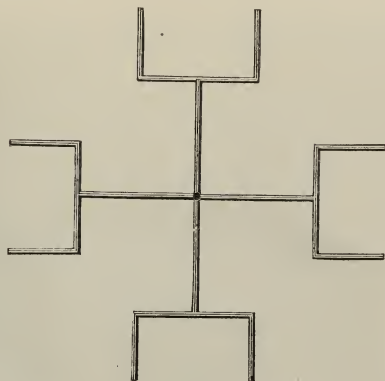


Fig. 9.

The operation is commenced by filling the boiling tanks one third to one half full of water, according to the quality of the crude material, as learned by experience. When the water is boiling hot, the crude borax is shoveled in until the solution has a density equal to 20° to 30° Beaumé's hydrometer. The hot solution is allowed to stand over night, the steam being turned off. In the morning the solution, now free from sand and other mechanical impurity, is run off into crystallizers of No. 14 galvanized sheet iron. These vessels are square, seven feet at the bottom and six feet at the top. They are provided with covers of No. 16 galvanized sheet iron. As the solution cools, crystals of borax form in these crystallizers in crusts varying from half an inch to four inches in thickness. As soon as the boiling tanks are discharged, the mud is sluiced out; they are then pumped partly full of water for the next operation. When crystals cease to form in the crystallizers the mother liquor is drawn off, and the crystals removed from the sides and bottom, and returned to the clean boiling tanks in which they are redissolved and allowed to stand for a time undisturbed, as in the first operation, when the solutions are drawn again into the crystallizers. The result is *concentrated* borax. The mother liquors from both operations are run off into shallow pans of wood, covering half an acre, in which solar evaporation takes place, salts containing some borax crystallize out, after which the very impure mother liquor is allowed to go to waste. The plan of calcining to remove organic matter has never been practiced, although it should be.

The hot liquors are drawn from the surface in the boiling tanks by an ingenious device, which consists of a *goose-neck* of three-inch iron pipe, connected with a common flexible hose of the same diameter. The joints are common elbows and nipples. A three-inch pipe passes up through the bottom of each boiling tank near one side. The boiling tanks are set in a row, fifteen feet above the crystallizers; the pipe rises a few inches above the bottom, to allow for the settling mud. On the end of this pipe a common elbow is loosely screwed; in this is screwed a nipple, another elbow, and a length of pipe nearly as long as the bottom of the tank. This long pipe turns freely, and can



be elevated or depressed at pleasure, and extends obliquely to the surface of the fluid. The elbows are all loose, being only screwed hand tight. When it is required to draw off the liquors, the end of the pipe is depressed, until the opening is just below the surface. The solution flows down through the pipe without disturbing the sediment. By means of the hose, the liquors are conveyed to either of the crystallizers at pleasure.

Figure 10 shows the boiling tank and goose-neck in section.

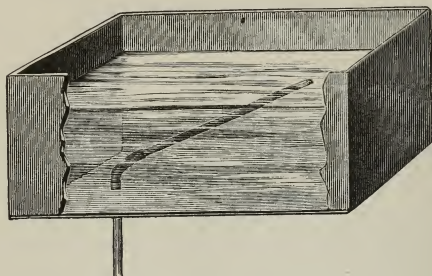


Fig. 10.

#### RHODES' MARSH.

The following description is condensed from a report by J. R. Scupham, C. E.:

Rhodes' Marsh, Esmeralda County, State of Nevada, occupies the western portion of a valley about twelve miles in diameter, surrounded by ranges of hills and isolated mountains. From a height the so called "marsh" resembles a frozen lake covered with dirty snow. The line of the Carson and Colorado Railroad is seen crossing its western edge, with the depot and borax works upon this portion, and long lines of spur tracks from the railroad radiating out on its surface.

The most concentrated portion of the marsh contains about two thousand three hundred and fifty-seven acres. But borate of lime and other borax compounds are found over a surface of four thousand acres, all of which land is the property of the "Nevada Salt and Borax Company."

Though termed a marsh, there is no water on the surface, except where springs here and there wet a small patch, or send out rills which soon sink beneath the surface.

On close inspection the whole surface of the marsh is found to be incrustated with various salts, while here and there are patches covered with snow-like efflorescence.

A close inspection shows also some difference in the character of portions of the marsh. Beginning at a point near the center of the western margin and following north in a strip varying in width, and also along the whole northern and northeastern portion, is a belt of the marsh, containing, under a brownish, salty crust, disseminated through six or eight feet of clay, masses and beds of snowball-like concretions of borate of lime, called here "cotton balls" or *ulerite*. This portion of the marsh contains about six hundred acres. The cotton balls can be easily gathered from the mud matrix, especially where they lie in thick beds, as they do in patches acres in extent.

These "cotton balls" look like a dirty snowball when first taken from the mud. When broken open they are found of a wavy, fibrous texture, white, with a silky or pearly luster. They vary in size from that of a pea to four inches in diameter.

These balls of borate of lime are also found occasionally through other portions of the marsh, sometimes even in the solid beds of salt.

The lowest portion of the marsh has a slightly undulating surface, and a thick, hard crust, containing, with chloride of sodium, a large amount of biborate of sodium and borate of lime. Under this crust is a solid bed of pure salt (chloride of sodium) eight to twelve feet thick. Long trenches are opened in this salt four to five feet deep, twelve feet in width, and as long as desired. The old salt removed is shoveled on to cars and sold for use in the quartz mills at nine dollars per ton. The bottom of the trench, when the old salt is removed, fills rapidly with a clear, sparkling water, intensely salt. In this water crystals of salt immediately begin to form and fall to the bottom in a snow-white deposit. In ten days six or eight inches in depth

will have formed. It is then shoveled on to cars and taken to the works to be ground up for fine table salt. This is purer than the best Liverpool salt, and the production costs, besides the sacking, not more than eighty cents per ton delivered at the railroad. There are about four hundred acres of this salt ground.

South of the salt beds, lying in a zone about one and a half miles long, in the center of the marsh, is a tract of about four hundred and eighty acres, containing tinal (native borax crystals). This is the richest and by far the most interesting portion of the marsh. For three or four feet in depth the material is a stiff gray mud, through which are thickly disseminated the translucent gray crystals of tinal. These crystals are from the size of a grain of wheat to two inches in length by one inch in diameter.

Underneath this tinal mud is a solid surface exactly like ice and called by that name here. It is sulphate of soda with some borax. This solid "ice," so far as I know, has never yet been cut through. At one place I saw it cut into six feet, all the way showing like solid dusky ice.

That portion of the marsh lying west, south, and east of the tinal deposit, containing in all about two thousand acres, is covered with a crust from two to six inches deep, containing biborate of soda in a powdered state, mixed with hard clay.

As it only requires the simplest treatment to produce borax from this for the market, the company is confining its attention entirely to this section at present, and it will be years before any other source need be touched.

The amount of sulphate of soda underlying all these borax beds is well worthy of consideration, as caustic soda and carbonate of soda can be made from it sufficient to supply the American market. And as the uses of these chemicals is greatly on the increase, their production might become a source of great revenue to the company. At present these soda salts are largely manufactured from cryolite, imported from Greenland.

The work of producing borax out of such excellent material is very simple. Indeed, the borax is already there and only requires dissolving from the adulterating mud and recrystallizing.

At the railroad station, on the western portion of the marsh, the company has its works, consisting of a warehouse, an engine and boiler-house, four boiler-tanks (7x8), twenty-four crystallizing tanks, waste tanks, etc.

The company has also a salt mill in the warehouse for grinding table salt.

The attention of the company will be confined, for a decade at least, to the manufacture of borax from the native borate of soda. To do this, the top crust to the depth of six inches is shoveled into cars, taken to the works, and dumped into the boiling tanks, which are partly filled with water from a well strongly impregnated with borax. The tanks are then boiled by steam from the boilers until the borate of soda is all dissolved, when it is allowed to settle. The water containing the solution is then decanted into the crystallizing tanks, which are of galvanized iron, with sheets of the same material suspended in them. Here the borax crystals form on the sides and on the plates to the depth of about two inches. The water is then run off into the waste reservoir and saved, for it still contains some borax. The borax crystals are knocked off and shoveled up. This constitutes the "crude borax" of commerce, really worth more than the "refined," because it contains an excess of boracic acid. This is now redissolved and mixed with carbonate of soda, to reduce it to the standard. At 18° Beaumé it is again decanted into crystallizing tanks, where "refined borax" is finally formed.

The capacity of these is calculated for fifty tons per month and for some time they have been producing at fully that rate.

What has been shipped has proved to be the very best in the market.

With these works running smoothly, borax can be produced at ten dollars per ton.

As I have before stated, the amount of the product is dependent on the will of the company. The raw material in the marsh is practically unlimited and the capacity of the present works can be increased four or five times, simply by adding tanks and boilers.

It costs \$12 50 per ton to freight borax from Rhodes' Marsh to San Francisco.

The "Nevada Salt and Borax Company" is incorporated under the laws of California, with 100,000 shares of stock, at a par value of \$10 per share. Besides this, bonds were issued for \$100,000, and the money used to purchase and equip the property. These bonds run fifteen years, and bear interest at seven per cent. United States patents are issued for all the lands of the company, consisting of 4,160 acres.

The following are the analyses of the samples taken from different locations, which were made by A. A. Hebbeling, chemist, United States Mint, Carson City, Nevada, March, 1882:

No. 1, Borax—From the southeast part of the marsh, about a mile and a half from the house of Messrs. Rhodes and Wason—is the crude borate of soda. The material covers the surface to the depth of from one to five inches, and embraces an area of about forty acres.

## ANALYSIS.

Borate of sodium.....	40.06
Borate of calcium.....	1.16
Sulphate of sodium.....	16.00
Carbonate of sodium.....	5.00
Chloride of sodium.....	8.07
Organic matter, sand and iron.....	29.71

100.00

No. 2, Borax—Taken directly north of place mentioned above. It covers about one hundred acres of ground to the depth of from two to eight inches, and will furnish a splendid material for manufacturing borax. Mr. Wason supposed this material to contain free "boracic acid," but it does not, as is shown by the presence of free carbonate of soda.

ANALYSIS.	
Borate of sodium.....	57.20
Borate of calcium.....	5.80
Sulphate of sodium.....	10.70
Chloride of sodium.....	9.00
Organic matter and sand.....	17.30
	<hr/> 100.00

No. 3, Salt Crust—A small deposit around Rabbit Springs, and hardly worth mentioning.

ANALYSIS.	
Carbonate of soda.....	19.6
Sulphate of soda.....	8.7
Borate of sodium.....	10.0
Sand and insoluble matter.....	61.7
	<hr/> 100.0

No. 4—Siftings from cotton balls. Very rich in borate of lime.

No. 5—Sample from ground running southwest to northeast, around east side of marsh. This is a very important part of the marsh, as it covers a large area of ground, and is capped by a crust of salt, containing a large per cent of borax. The cotton balls are found under ground, from half a foot to six feet deep.

No. 6, Soda—Crust from top overlying borate of lime, about one and a half miles north of house. It covers considerable ground, with a fine deposit of borate of lime underneath.

No. 7, Salt Crust—Thickness from two to six inches, overlying a fine and large deposit of borate of lime. It is two miles from the house, a little west of north.

ANALYSIS.	
Carbonate of soda.....	8.07
Chloride of soda.....	15.90
Sulphate of soda.....	20.10
Borate of soda.....	15.05
Sand.....	40.88
	<hr/> 100.00

No. 8—Sulphate of soda and lime.

No. 9—Sample from the vicinity of salt beds.

ANALYSIS.	
Borate of sodium.....	14.6
Sulphate of sodium.....	30.5
Chloride of sodium.....	26.6
Carbonate of sodium.....	trace
Sand and clay.....	38.3
	<hr/> 100.0

Nos. 10, 11, 12—Contain sulphate of sodium, with but trace of borax.

No. 13, Brown Crust—One and a half miles west of house. The center of a very extensive deposit of natural crystals of borax, called "tincal," extending from the surface of the ground to a depth of three or four feet. Even the brown crust overlying the clay containing the crystals is very rich in borax.

ANALYSIS.	
Borate of sodium.....	36.5
Sulphate of sodium.....	16.5
Carbonate of sodium.....	6.8
Chloride of sodium.....	15.0
Earthy particles.....	25.2
	<hr/> 100.0

The sample of water near "Borax Spring" yields 120 pounds of borax to the ton.

Rhodes Marsh lies in Sections 14, 15, 16, 21, and 22, township 5 north, range 35 east, Mount Diablo base and meridian.

The following letter from Professor Joseph LeConte is given here by his permission :

BERKELEY, CAL., November 1, 1882.

MR. J. R. SCUPHAM :

DEAR SIR: At your request I hereby give you a brief sketch of my observations at Rhodes' Salt Marsh. I wish you, however, to understand that the object of my visit was purely scientific, and therefore I made no attempt to form an accurate estimate, based on personal observation, of the actual quantity of valuable salts in the marsh.

The marsh is nearly circular in form, and, as near as I can judge, about two and one half to three miles in diameter, and contains about five or six square miles. The central part (perhaps one square mile or more) is covered with pure salt—chloride of sodium. Around this, to the margin, the nature of the deposit differs in different parts. In some parts borax in the form of crust; in some, borax in the form of tincal; in some, ulexite (a soda-lime borate); in some, sulphate of soda, and in some, carbonate of soda. Common salt is found nearly everywhere, more or less mingled with the other salts, but in a pure condition only in the central portion of the marsh. I will take up these successively :

1. *Common Salt.* This exists in practically unlimited quantity, and can be gathered in a chemically pure state, with apparently no more trouble or expense than would be necessary to gather so much earth. This is so obvious to every observer that nothing more need be said.

2. *Borax.* Borates exist here in three forms. (a) It occurs as a borax crust from one to three inches thick, more or less mingled with earth, the borax being perhaps fifty per cent of the weight. It is easily gathered with a shovel. I do not know the exact area of this crust, but it is evidently very large. I observed, also, places where the crust had been removed a year or two ago, and on which it had been re-formed, although not yet so thickly as before removal. The most extensive crust area is on the southern portion of the marsh, not far from the works. Several springs containing borax in this vicinity suggest the mode in which the crust was formed.

(b) Borax occurs also as tincal. In many parts of the marsh, notably on the west, southwest, and southeast of the central *salt area*, if the loose surface earth be removed until stiff, moist, blue clay is reached, and then a spadeful of this blue clay be turned up, it is found to be full of transparent crystals from a half inch to one inch in diameter, looking like fragments of ice. These crystals are pure borate of soda, or borax, in the form called tincal. Some spadefuls thus turned up, I think contain fifty per cent of tincal. Of course I only turned up the soil here and there to examine the mode of occurrence. I am sure, however, that this form of borax occurs over a very wide area, but whether universally, or equally distributed, I cannot say. My chief interest was the question of the formation of these crystals. This point is still obscure, but they must have crystallized from a saturated solution, and therefore, in addition to the crystals, a considerable amount of borax crust exists in solution in the water which saturates the clay.

(c) Borate occurs also, and probably in very large quantities, as ulexite, or soda-lime-borate, or "cotton balls." These curious balls occur in a semicircular area surrounding the central salt area on the north, northwest, and northeast. They are imbedded in a wet, stiff clay, like the tincal, and are gathered in the same way. When the loose earth is removed to the depth of a foot or so, until the stiff clay is reached, then a spadeful of clay is seen to contain irregular ellipsoidal white balls, much the shape and size of potatoes, and may, in fact, be dug like potatoes. On breaking one of these, the beautiful, radiated, silky fibers characteristic of ulexite are seen. This substance occurs in large quantities in the places examined by me. The area over which it is found is also large. It is not unlikely that the largest quantity of borax is in this form. Of this, however, I cannot speak with confidence, having dug into the soil only in isolated spots.

As ulexite is a soda-lime-borate, it was probably formed by the reaction of solutions of borate of soda and bicarbonate of lime.

3. *Sulphate of Soda, or Glauber Salt.* The area occupied by this material is close about the *salt area*, and almost surrounding it except on the west. It is reached by removing the surface earth and then the clay to a certain depth. It is then seen as a solid, transparent mass, like a subterranean ice cake. In some places it was so thick that we were unable to cut through it. This sulphate, of course, can be used in the manufacture of carbonate of soda, as in the well known Le Blanc process.

4. *Carbonate of Soda.* In one place only did I find carbonate of soda in condition sufficiently pure to be utilized. This was near the road leading from the salt vats to Mr. Rhodes' house. It was in the form of soft crust two or three inches thick, but how extensive the deposit is is not known. Carbonate of soda, whether native, or made from sulphate of soda, could, of course, be used in changing ulexite into borax. On the next page I have drawn a rough sketch (Fig. 11) of the marsh and of the areas of the various salts spoken of above. I hope you will understand, however, that this makes no pretensions to accuracy. It is intended only to make clear what I have written.

I know not if you desire my views as to the mode of formation of these several salts. In fact I have no very decided views. If the marsh is a simple dried up lake, the waters of which contained all these salts, then it would be impossible to account for the *localization* of the various kinds. The former lake, therefore, must have been supplied also largely by springs coming up in the lake bottom, and these springs brought up various kinds of salts, some one kind and some another. After the lake dried up, these springs still continuing to act would



then commence to localize their products. This they are still doing. Thus I account for the localization of most of the kinds of salts. In addition to this, I think the common salt, as the most abundant ingredient of the lake water, was probably left everywhere as a crust, but subsequently was leached out, and accumulated in a very pure form in the lowest or central part. Of the manner in which the natural salt vats are formed I am not yet satisfied, but I think their rims are *built up* by water coming up through fissures and wetting these parts, and dust accumulating there because wet.

Yours, respectfully,

JOSEPH LECONTE.

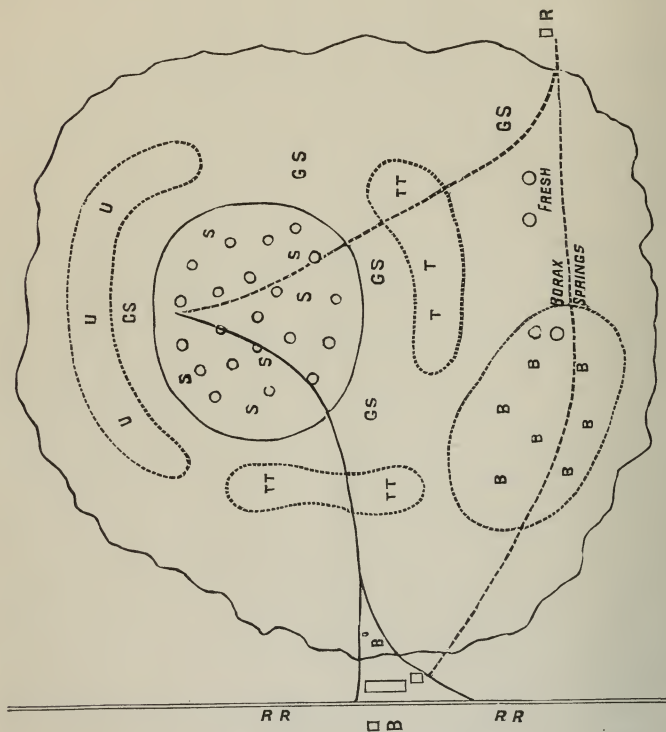


Fig. 11—S. S.—Salt vats; B. B.—Borax crust; T. T.—Tincal; G. S.—Glauber salt; U. U.—Ulexite; O. O.—Fresh Springs; R.—Rhodes' house; B.—Borax works; C. S.—Carbonate soda.

The following is the result of an examination of a sample of crude borax (tincal) from Rhodes' Marsh, made by me. The sample was furnished by J. R. Scupham, May, 1883. This material is an agglomeration of obscure crystals of anhydrous sulphate of soda (thenardite) in which are imbedded distinct and perfect crystals of borax; the whole covered with an efflorescence of a dirty white color, and intermixed with sand and fine gravel.

It has much the appearance of the crude borax from China, described by Fourcroy and quoted in this paper. When placed in water it softens, the borax crystals in a great measure separate, and may be picked out by hand. In experiments I made, I was able so

to separate very nearly all the borax, which amounted to about nine per cent of the whole. These crystals ranged in size from half an inch to one tenth of an inch in length, and even less. They were nearly all perfect, with sharp angles and edges, and all prismatic, proving that they had crystallized from dilute solutions. Some contained mechanical impurities inclosed, while the larger portion were perfectly pure and transparent. After the borax crystals were picked out by hand, the remainder was dissolved in water by application of heat, and the sand filtered off. This was dried, weighed, and found to be seven per cent of the whole. The clear solution was returned to the clean dish, and evaporated to a pellicle, during which no insoluble precipitate formed. The dish was then set aside to crystallize. The result was a large quantity of very beautiful crystals of hydrated sulphate of soda, in which no crystals of borax could be seen. To make sure, the mother liquor was poured off, and the crystals dissolved in successive portions of cold water. No borax remained, which proved that the mechanical operation of picking out had been complete.

These experiments show that this form of crude borax material can be refined without difficulty, and that it contains about ten per cent of borax.

At the same locality, in the blue mud of the lake, large isolated crystals of borax have been found, exactly resembling those at Borax Lake, in California. Some of these were several inches in length, and all contain impurities included within the crystal. I dissolved one of these crystals and weighed the impurity, which was found to be eight per cent, and was fine desert sand.

#### COLUMBUS BORAX MARSH, ESMERALDA COUNTY,

Lies about one hundred and fifty miles southeast from Carson, and about the same distance from Wadsworth. It is an irregular oval in form, ten miles long by seven miles wide. It is the same locality at which Mr. Troop obtained the cotton balls from which he made the first borax. At one time there were four companies at work—the Pacific Borax Company, Hearn's Steam Works, and the others. I am not informed as to what is being done at the present time.

#### FISH LAKE, ESMERALDA COUNTY,

Is a small basin situated about twenty-five miles south of Columbus. I believe the only company now in possession is the Saline Valley Borax Company, W. D. Linton, Superintendent, who intended to prepare a description of the lake and the borax works, but his report was not received in time for publication. At one time Fish Lake Valley was the scene of great activity. In May, 1873, Mr. Nadeau projected large works. Mott & Piper were producing two tons of concentrated borax daily. Mr. Nadeau did a large business hauling the product to a market.

The Pacific Borax Company, incorporated under the laws of California, had works and locations at Columbus and Fish Lake. The first Trustees were Justinian Caire, Robert Morrow, M. M. Tompkins, and I. Lawrence Pool. Michael Kane was President. The company located 15,200 acres of supposed borax lands. Their principal works were situated five miles from Columbus. In June, 1872, they employed eighteen men.

## PYRAMID LAKE.

The waters of this lake were examined by Mr. F. R. Waggoner and found to contain boracic acid. The following slip from a Nevada paper is given as an illustration of the extravagant construction some newspapers put upon a simple statement like the above. Similar publications have been made from time to time, which tend greatly to mislead the public and to impair confidence in legitimate enterprise.

## BORAX FOR THE WORLD.

HOW A COMPANY OF CAPITALISTS PROPOSE TO MAKE LARGE PROFITS FROM THE WATERS OF PYRAMID LAKE.

Pyramid Lake contains one quarter of one per cent borax and one per cent carbonate of soda, or one pound of borax and four pounds of soda to every 400 pounds of water. Dr. F. R. Waggoner has had his eye on the lake for several months, and at last the object of his frequent visits to its shores have leaked out. How the doctor will like to have his pet scheme exposed we do not know, but having found out what he intends to do, the public gets the benefit of a reporter's inquisitiveness, and if anybody has any objection to Waggoner's project let them be recorded at an early day. Dr. Waggoner, it is said, has organized a company of capitalists to erect works and carry on the manufacture of borax on a very extensive scale. The company will be known as the "Pyramid Lake Borax and Desert Land Company," and it is their intention to apply to the Secretary of the Interior for the privilege of turning the course of the Truckee River into Mud Lake, thereby shutting off the source of fresh water supply from Pyramid Lake. There is already an open channel from the river at a point one or two miles from its mouth to Mud Lake, and about one third of the water empties into that lake now. After the river is turned the company proposes to evaporate the waters of Pyramid by solar evaporation. They calculate that in ten years the lake will evaporate 300 feet, or one inch every twenty-four hours. At the expiration of that time large borax works will be erected at the lake, and the water will be pumped into large zinc vats, and by artificial evaporation they will be enabled to supply the world with borax. It is the intention of the company to devote their time and a large amount of money to the reclamation of desert land made valuable by changing the course of the river, while waiting the process of evaporation. Hundreds of thousands of acres of desert land can be made into magnificent farms by this means. The proposition may seem a gigantic undertaking, and perhaps a little visionary, but nevertheless it is possible, and time and money is all that is required to carry it out.

## LOCATION OF BORAX LANDS.

Deposits of borax may be located under the provisions of Title XXXII, Chapter 6, of the Revised Statutes of the United States, regulating the location of placer ground.

No one location made by an individual can exceed twenty acres, and no one location made by an association of individuals can exceed one hundred and sixty acres; which location of one hundred and sixty acres cannot be made by a less number than eight bona fide locators, and no local laws or mining regulations can restrict a placer location to less than twenty acres, although the locator is not compelled to take so much.

Where placer claims are upon surveyed public lands, the locations must be made to conform to legal subdivisions thereof as near as practicable.

The price to be paid for placer ground is five dollars per acre.

The following recent letter from the Secretary of the Interior to the Commissioner of the General Land Office, will be of interest to locators of borax deposits:

SECRETARY TELLER TO COMMISSIONER McFARLAND, JANUARY 30, 1883.

My attention is called to the fact that these deposits, although valuable, are not of sufficient value to permit their being entered under the mining laws. They ask whether the recent circular, approved by me September 22, 1882, and its amendment of December 9, 1882, is applicable to entries of lands containing borax and other similar valuable deposits.

It was early determined by the Department that the Act of May 10, 1882, which describes certain lands containing valuable mineral deposits, was applicable to land containing deposits of borax, carbonate and nitrate of soda, sulphur, alum, and asphalt; and I believe that from the passage of that law until the present time, the definition of the term, "valuable mineral deposits," has been such as to include the minerals and alkaline substances named. I understand that entries of borate lands have been allowed under the provisions of the Act of 1872, and the regulations made in accordance therewith.

It is the desire of persons interested, that the regulations which were in existence having special reference to the applications for patents for placer claims, namely, the circular of October 31, 1881, should be continued in force, so far as they relate to deposits of borax, etc., as mentioned above. Believing that practical effect should be given to the mining laws of the United States, I am of the opinion that to apply the new regulations to such entries would result in excluding such lands from sale, and depriving the people of the benefit of the use of these natural deposits. I therefore direct you to permit the entry of public lands containing valuable deposits of borax, carbonate and nitrate of soda, sulphur, alum, and asphalt, in the States of California and Nevada and the Territories of Arizona and Wyoming, in which section of the country I am informed these deposits are present, under the regulations of October 31, 1881. In addition, however, an applicant for a patent for public lands containing deposits of borax, etc., as above, must affirmatively show that the lands entered are not valuable for any other purpose than the one for which the application is made. It will therefore follow that the circulars of September 22 and December 9, 1882, are not applicable to entries of the lands thus described and excepted. [*Copp's Land Owner*, Vol. 9, No. 11, February, 1883, page 210.]

#### CALIFORNIA AND NEVADA BORAX COMPANIES.

San Bernardino Borax Mining Company, S. Riddell, President.

Inyo Borax Company, of Inyo County, California; Greenland Salt and Borax Company, California; Amargosa Borax Mining Company, California, William T. Coleman & Co., Agents.

Teel's Marsh Borax Company, of Esmeralda County, Nevada, Smith Bros.

Pacific Borax Company, of Columbus, Nevada, F. M. Smith.

Nevada Salt and Borax Company, C. Van Dyck Hubbard, Secretary.

Saline Valley Borax Company, Fish Lake, Esmeralda County, Nevada, W. D. Linton, Superintendent.

Eagle Borax Company, Inyo County, I. Daunet, President.

#### BORACIC ACID.

Boric acid (English); acide borique (French); borsauere (German); acidum boracis, sal seditivum Hombergii, sal narcoticum vitrioli (Latin).

Names given to boracic acid by the old chemists: Flores boracis, sal volatile vitrioli, flores vitrioli philosophici, sal volatile narcoticum, sal album alchymistarum.

Boracic acid was discovered in 1702, by Homberg, a Dutch chemist, which he produced by subliming a mixture of sulphate of iron and borax.

Chaptal (Elements of Chemistry, London, 1808) describes Homberg's method of producing boracic acid, or the acid of borax, as follows:

When it is proposed to obtain it by sublimation, three or four pounds of calcined sulphate of iron and two ounces of borate of soda are dissolved in three pounds of water; the solution is filtered and evaporated to a pellicle, after which the sublimation is performed in a cucurbit of glass with its head. The acid of borax attaches itself to the internal surface of the head, from which it may be swept with a feather.

That the old chemists knew but little concerning the nature of boracic acid may be inferred from the following quotations:



## FROM THE CHEMICAL WORKS OF CASPER NEUMAN, VOL. I, LONDON, 1773.

The mineral alkali appears from experiment to be a principal ingredient of borax. On treating borax with acids, about one fourth its weight of a peculiar saline substance (called sedative salt) is separated, and the residuum proves a combination of the alkali with the acid employed; thus, when the marine acid is used, a genuine sea salt remains; when the nitrous, a quadrangular nitre; and when the vitriolic, a sal mirabile. The substance separated joined to the mineral alkali, to the basis of sea salt, or to the salt of kali, recomposes borax again.

The properties of this substance so far as they are known, are these: It is of a bright, snowy whiteness, extremely light, composed of fine plates or scales, and as it were unctuous to the touch, of no smell, of a bitterish taste, accompanied with a slight impression of coldness.

It dissolves difficultly in boiling water, and on the liquor's cooling, crystallizes on its surface into thin plates, which uniting and becoming larger, fall to the bottom. It likewise dissolves, by the assistance of heat, in rectified spirits of wine; the solution set on fire burns with a green flame.

Moistened and exposed to a considerable heat, it in part sublimes; by repeated humectations the whole may be elevated. Whilst dry, it proves perfectly fixed; it melts, emits aqueous vapors, and runs into a vitreous substance, dissoluble again as at first; neither the glass or the salt itself are affected by the air. It makes no change in the color of blue flowers. It unites with the common alkaline salts, in some degree neutralizes, and renders them capable of crystallization. It is said to expel from alkalies every acid except the vitriolic, though expelled itself by every acid, from the alkaline basis of the borax.

\* \* \* \* \*

The principal preparation of borax is a white volatile saline concrete, called *Flores boracis*, *sal volatile vitrioli*, *Flores vitrioli philosophici*, *sal volatile narcotinum*, and by some *sal album alchymistarum*. This is made sometimes with the *caput mortuum* of vitriol, and sometimes oil of vitriol. Three pounds of the *caput mortuum* or colothar of green vitriol are elixated with six or seven quarts of boiling water, and the filtered liquor mixed with a solution of two ounces of borax in a quart of boiling water. The mixture suffered to settle for twelve hours, and poured off clear from the sediment, is evaporated to two pounds, or a quart, then put into a glass body and treated with a gradual fire; a fine sparkling sublimate arises, which, after the vessels have grown cold, is to be swept out with a feather. If the phlegm which comes over be returned on the residuum, a little more sublimate may be obtained, and thus repeatedly for a second and third time. The method of preparing the salt with oil of vitriol is, to dissolve two ounces of borax in a quart of water, gradually drop into the solution one ounce of oil of vitriol, evaporate about one third of the mixture, and then distill and cohobate as before. This salt was first discovered by Mr. Homberg, and is used by French physicians in fevers and ebullitions of the blood, in deliria, convulsions, hypochondriacal and hysterical affections. Its particular nature is as yet unknown; it has no volatile smell or pungent taste and appears to be of the neutral kind. I have prepared this salt by a more commodious method than that of Homberg, without sublimation or distillation. A solution of borax being mixed to saturation with a solution of alum the earth of the alum precipitates; the remaining liquor evaporated to a certain pitch and set to shoot, yields first fine crystals, the same with the sublimed flowers. If the process be continued, the crystals which shoot afterwards are found to be of a different kind.

## FROM ELEMENTS OF NATURAL HISTORY AND CHEMISTRY, BY M. FOURCROY, 1790.

A diversity of opinion prevails concerning the nature and the formation of the boracic acid. A number of chemists have believed it to be an intimate combination of the sulphuric acid and a vitrifiable earth with a fat matter. Messrs. Boudelin and Cadet think it to be formed by the muriatic acid. The latter of these two gentlemen thinks that it must contain a small quantity of earth of copper, because it has the same property with the oxides of copper, of communicating a green color to the flame of combustible bodies. Cartheuser assures us, that on drying and calcining by the action of a slow fire, a quantity of the boracic acid in a state of great purity, he observed it to emit vapors of muriatic acid, and on dissolving this salt thus dried, and filtering the solution, he found a gray earth remaining after the filtration; and, lastly, that by many repetitions of this calcination and solution, he at length accomplished the entire decomposition of the boracic acid, and found it to be a modification of the muriatic rendered fixed by an earth. This experiment has been repeated by Messrs. Maegner and Poulletier de la Salle. They observed an odorless vapor to be disengaged during the calcination of this salt, but they were not able to distinguish from its smell that it was muriatic acid. By repeated desiccations and solutions they obtained a small portion of gray earth; but this earth when united with the muriatic acid, did not form sedative salt, as Cartheuser had given out, and of consequence this chemist's opinion appears to be no better supported than the rest. Model thought this salt to be a combination of a peculiar alkali with the sulphuric acid, which is used in disengaging it. But this opinion cannot be admitted, for the boracic acid is always the same, whatever be the acid to precipitate it. M. Baumé says that he found means to produce the boracic acid by leaving a mixture of grease and clay to macerate for eighteen months. At the end of that time he obtained from it by lixiviation a salt in small scales, with all the properties of *sedative salt*. From this he concludes the boracic acid to be a combination of the acid of grease with a very fine earth, which it is impossible to separate entirely from it. He adds, that the same salt may

be produced with vegetable oils, but more slowly. M. Wiegleb repeated M. Baumé's experiment, but without obtaining boracic acid.

Chemists at present think this to be a peculiar acid, differing from all others, and possessing certain characteristics of its own. Its elective attractions with alkaline bases are arranged by Bergman in the following order: lime, barytes, magnesia, potash, soda, ammoniac. As they differ greatly from those of other acids above examined, they afford an additional proof of the peculiarity of the nature of this acid, whose compound principles remain still unknown. The use of the boracic acid in medicine was first introduced by Homberg, who ascribed to it quieting narcotic qualities, and gave it the name of sedative salt or volatile narcotic salt of vitriol; because he had obtained it by subliming nitre and vitriol. But experience has since shown the medical virtues of this salt to be but very moderate; at least it must be given in a much stronger dose than Homberg has directed, in order to produce the effects he ascribed to it; and it is very properly rejected, as we have many other medicines of the same class whose effects are much more certain.

The method of setting boracic acid free by sublimation and the use of sulphuric acid has been described. It is more conveniently obtained by dissolving borax in two and a half parts of boiling water and adding hydrochloric acid until the solution reacts strongly acid to test paper. Common salt is formed, and the boracic acid set free crystallizes out in thin shining plates, which retain water with considerable tenacity. The acid being but sparingly soluble in cold water may be purified by washing in that fluid, drying and recrystallizing from boiling water. When dried on clean bibulous paper, it becomes a beautifully white scaly powder, which, under the microscope, is seen to be in hexagonal scales, and in rouleaux of crystals, like blood corpuscles, or piles of coin.

When carefully prepared it is a most beautiful microscopic object, best seen on a dark field and lighted with a parabola. It may be recognized under all circumstances when its appearance has become familiar to the observer.



Fig. 12.—Boracic acid crystallized from solution, as seen under the microscope magnified 21 diameters. Drawn with the camera Lucida. (A) Rouleau of crystals.

## PERCENTAGE COMPOSITION OF BORACIC ACID.

Boracic acid -----	56.4
Water-----	43.6
	<hr/> 100.0

## CHEMICAL EQUIVALENT.

Boracic acid-----	35.03
Water-----	27.00
	<hr/> 62.03

Boracic acid is soluble in 27 times its weight of water at 60°, and in 2.96 parts of water at 212°. The hydrated acid dissolves in alcohol, which burns with a characteristic green flame, seen even in the presence of soda salts, which impart a yellow color to the flame. But if soda is largely in excess, the green color is masked, and can only be observed when the alcohol is nearly consumed, and the distinguishing color is more marked if the expiring flame is gently agitated by breathing upon it, but under these circumstances a good eye is required to distinguish the color. By far the best color test is made by the use of the direct vision spectroscope, which shows three distinct pale green bands in the green part of the spectrum. I have used the beautiful little instrument made by Browning, of London, and which is shown in figure 13:

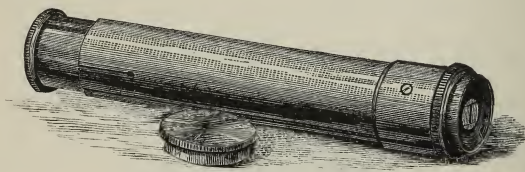


Fig. 13.

The use of this instrument is simple, and once seen is easily understood and practiced. The substance supposed to contain boracic acid is placed in an evaporating dish, and a few drops of sulphuric acid added. A brisk effervescence generally takes place. The contents of the dish must be stirred, which may be done with a small stick, or anything convenient at hand. Alcohol is then poured in, in small quantity, and ignited. All that is then required to determine the presence of borax or boracic acid is to look at the flame through the spectroscope. Three distinct and beautifully green bands will be seen if boracic acid is present.

If *free* boracic acid is contained in the sample, the green bands may be produced without the introduction of sulphuric acid. It is best, however, always to use the acid, which decomposes the salt containing the weaker boracic acid, and to make a secondary test to prove the boracic acid to be free or otherwise.

The experiment should be made in a dark room. The bands are best seen when the slit is so far closed as to show the sodium band, always present, as a very narrow line. Figure 14 shows the bands of boracic acid as seen in the spectroscope.



Fig. 14—Spectrum of boracic acid; the yellow is the sodium band always seen.

With the spectroscope, a bottle of strong sulphuric acid, one of alcohol, and a small evaporating dish, the prospector, although unskilled in chemical handicraft, may detect with unerring certainty the presence or otherwise of boracic acid or any of its salts in the deposits he may find.

When boracic acid is suspected in steam issuing from hot springs, it is only necessary to condense a portion of the steam. The resulting water is evaporated nearly to dryness at a *very gentle* heat; alcohol is then added and the flame examined as before. This test shows the presence of boracic acid in the waters of Mono Lake, and in the eruptive mud from the mud volcanoes of the Colorado Desert, San Diego County.

The only weak point in this determination lies in its extreme delicacy. In inexperienced hands it might lead to the hope that the sample was rich when boracic acid was present only in small quantities; but a little experience will correct this, for it will be seen that when the quantity is small the bands are faint, and come and go in an intermittent manner; while, if the quantity is large, they are distinct and well defined, and the color a clear green. As with the sodium band, the intensity of the color is an index to quantity—all of which may be learned by experience. In making this determination all bands of other substances present, as lithium, potassium, etc., must be disregarded.

In prospecting the deserts, there are no facilities for chemical operations, and the prospector, generally poor, can but ill afford to send his samples to San Francisco, or pay the cost of chemical analysis. These considerations have no doubt retarded the development of the borax interests of the State.

It is sometimes inconvenient to use alcohol in the manner described. The experiment can be made with equal facility in the flame of a Bunsen gas burner, or spirit lamp.

The substance to be examined is supported in a loop of platinum wire. The wire may be held in the hand when the color is to be observed by the unassisted eye, but when the spectroscope is used it must be supported. A convenient support may be improvised in the following manner: A small glass funnel is placed on the table with the tube part upwards. A glass rod or wire small enough to pass easily into the tube, is cut to a convenient length, wrapped with paper, and pushed into the tube of the funnel. The paper acts as packing, and when arranged the rod may be raised or depressed by pushing up or down in the tube. A common cork, of medium size, is pierced with a cork borer diametrically, and placed on the rod. A wire is thrust through the cork at right angles with the vertical rod. This wire may be three or four inches in length.

A small glass tube may then be selected and cut to the length of an inch and a half. One end is closed in the blowpipe flame, and a short piece of platinum wire inserted while the glass is still hot; when cold the wire will be firmly set in the closed end of the tube; the other is open. In the end of the platinum wire a small loop is made; when all is ready the substance is ground in an agate mortar with a small excess of a mixture of equal parts of bisulphate of potash and fluorspar. The platinum wire is first held in the flame for a moment to see that it is clean and gives no color. The flame is examined to be sure that no color is imparted by any uncleanness of the burner. If the flame is blue, and perfectly non-luminous, it may be observed



through the spectroscope, and if no color is seen except the bright yellow sodium band the apparatus is ready for use. To make the experiment, the Bunsen burner is lighted, and a full head of gas turned on, making the flame five or six inches long. The glass tube with its platinum wire and loop is slipped off from the horizontal wire, and the loop dipped into a small vessel of distilled water, and then into the mixture in the agate mortar. The tube is then replaced on the wire, and the whole stand pushed near the flame with the loop and the assay about half an inch above the top of the burner. The spectroscope is then held to the eye in the left hand, while the stand is gently pushed with the right until the substance to be examined touches the flame. The green bands will instantly appear if boracic acid is present. This description will be fully understood by a glance at the following engraving:

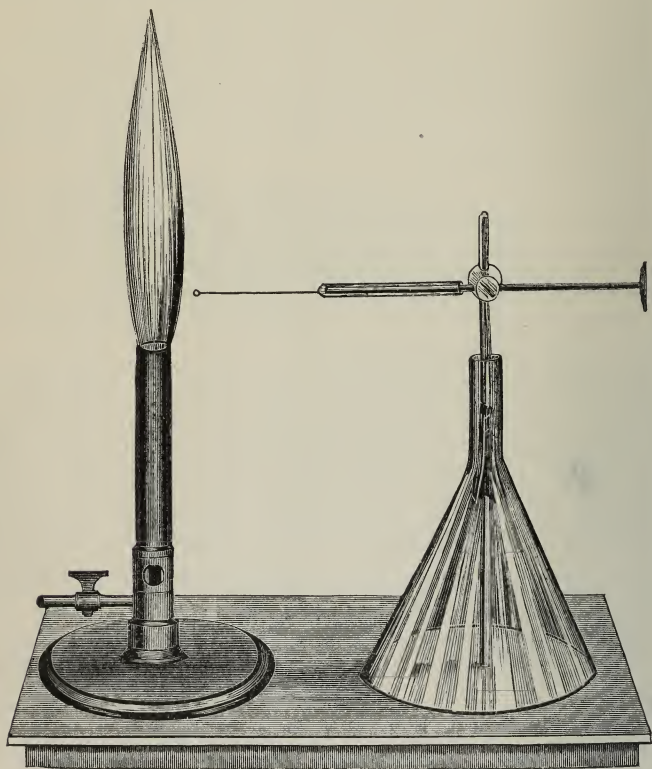


Fig. 15—Apparatus for observing the green color of burning boracic acid, scale  $\frac{1}{2}$ .

Bisulphate of potash is prepared by placing a convenient quantity of powdered sulphate of potash in a porcelain capsule and wetting it

with concentrated sulphuric acid. The mixture must be heated until no more white fumes are given off, and a small portion taken out on a glass rod cools into a hard coating. The heat employed must be sufficiently great to keep the mixture in a state of fusion until the excess of acid is driven off. When cold, the mass must be pulverized and kept in a glass-stoppered bottle for use.

#### NATIVE BORACIC ACID

Is known to the mineralogist as *Sassolite*, or *Sassoline*, named from Sasso, in Italy, where it was first found in a solid state by Mascagni. It occurs also abundantly in the extinct crater of a volcano in one of the Lapary Islands, near Sicily, as mentioned elsewhere, at which locality it was discovered in 1813 by Dr. Holland. It is found, also, in crevices and fissures in the craters of active volcanoes. During the eruption of Vesuvius, in 1851, this mineral was found in fissures in Torre Del Greco. It has been obtained, also, from the crater of Stromboli, an active volcano on an island of the same name, one of the Lapari Group. It exists, also, in solution in mineral waters of Germany and elsewhere, notably Wiesbaden, Aachen, and Krakenheil.

*Boracic acid*, free or combined, is of common occurrence on the Pacific Coast. It has been found in the waters of the ocean along the shores of California and Oregon. Common salt, made by evaporating the sea water, contains more than traces of boracic acid. According to Professor W. P. Blake, it occurs in a free state in the water of Clear Lake. The discovery of this acid in mineral water in Tehama County led to the examination of other springs then known, which resulted in the finding of boracic acid in nearly all of them. It was discovered at the mud volcanoes in San Diego County by Dr. Veatch, which was verified by my own observation. An account of this interesting locality will be found in the second annual report of the State Mineralogist, folio 227.

*Sassolite*, of the books, is said to crystallize, in the triclinic system, but all the specimens I have seen show under the microscope a confusion of broken scales without any well defined crystals. When magnified it has almost exactly the appearance of selenite, with the same apparent cleavage and pearly luster. When closely examined, obscure hexagonal plates, imbedded in the pearly mass, may sometimes be distinguished.

Sassolite fuses easily, coloring the blowpipe flame at the same time transiently green; gives water in a closed glass tube; color, white-yellowish, and sometimes a dirty brown; hardness, 1 to 1.48; chemical formula,  $\text{BO}_3 + 3\text{HO}$ .

#### PERCENTAGE COMPOSITION.

Boracic acid .....	56.45
Water .....	43.55
	<hr/> 100.00

## SOLUBILITY OF CRYSTALLIZED BORACIC ACID IN WATER.

Temperature.		Solution in parts of water.	One hundred parts of water dissolves—	Saturated aqueous solu- tion contains per cent BO <sub>3</sub> + 3HO.
Centigrade.	Fahrenheit.			
18.7	65.7	25.66	3.9 parts	3.75
25.0	77.0	14.88	6.8 parts	6.27
37.5	99.5	12.66	7.8 parts	7.32
50.0	122.0	10.16	9.8 parts	8.96
62.5	144.5	6.12	16.0 parts	14.04
75.0	167.0	4.73	21.0 parts	17.44
87.5	189.5	3.55	28.0 parts	21.95
100.0	212.0	2.97	34.0 parts	25.17

Boracic acid was discovered in a natural state in Italy in 1777, by Hœffer, chemist to the Grand Duke of Tuscany.

The following extracts from the works on the geology and mineral resources of Central Italy, by W. P. Jervis, Conservator of the Royal Museum of Turin, Italy, may be accepted as full and reliable. Not only a history is given, but also the details of the manufacture:

In 1742, Targioni Tozzetti, a scientific Tuscan traveler, visited the salt works of Volterra in his rambles through the Maremma, and proceeded southward through Pisanance to Monte Cerboli, in order to examine the curious phenomenon of hot vapors which abounded in the neighborhood. He relates how he took a stroll through the valley which stretches southeast from Monte Cerboli, and reached the little torrent Possera. All around him was a scene of desolation, well fitted to strike dismay on the ignorant, but eminently suited to the contemplative mind of the naturalist, to whom the most dreary plains and barren rocks yield ample subject for useful and agreeable study. His attention, however, was soon attracted to the scene around him. He stood close to a yawning gulf, from which issued rumbling noises and disagreeable odors. He wished to look down and peep into the mysterious chasm to learn something of its nature, but his temerity was rewarded by a surly growl from within, and his guide told him that the noise sometimes resembled a hundred bellows, as if Vulcan himself were at work, while flames issued forth at night after very hot days. Though he saw no fire, the vapors served as a warning to keep him at a considerable distance; but before long he came upon more vapor vents, *soffioni*, and the little *lagoni*, or ponds of muddy blue water, boiling vehemently, the imprisoned gas producing bubbles, increasing in size till sufficiently large to cause them to burst. Dense white vapors, smelling strongly of rotten eggs, rose from the *lagoni* and ascended to a considerable height into the atmosphere. The ground on which he stood was soft and crumbled under his feet; the decomposed rocks, and some of the efflorescent minerals, were new to him, and the subject of many curious speculations. The whole of the valley was apparently studded with such lagoons, an attempt to define the number of which was futile, connected, as they were in many places, by cross fissures and superficial cracks. Not a tree was visible throughout the whole extent of the valley. The opening of a new fissure was the signal for the destruction of all neighboring shrubs, scorched by the subterranean heat. Occasionally, he was told, the *lagoni* would be overcharged by the rain, and their contents flow into the Possera, where the heat would kill all the fish for a considerable distance down its course, the density of the atmosphere in cloudy weather pressing on the columns of vapor, causing them to lie more close to the ground and spread themselves horizontally, while the grumbling sounds in the bowels of the earth redoubled in fury. Passing on toward Castelnuovo, the same lagoons were abundant, but of smaller dimensions, and according to tradition, they were on the increase; on the other hand, old lagoons dried up, only emitting steam at intervals.

A farmhouse near Castelnuovo, built 200 years before, had been suddenly undermined, a *fumacchio*, or incipient lagoon, having unceremoniously made its appearance in the kitchen, rapidly assuming the dimensions of a true lagoon. The inhabitants were utterly defenseless, and bade adieu to their ancestral tenement, the stone walls of which were soon attacked by the corroding influence of the vapors, and speedily destined, as our traveler truly predicted, to crumble to pieces. Within certain limits fertile fields were subject to be laid waste, and poisonous gases escaped, which had on several occasions proved fatal. Thus he relates how a swineherd in charge of forty pigs had been overtaken by the noxious gases; all the poor animals were killed but one. Another man, who was working in an alabaster pit, was suddenly overpowered by the escape of mephitic gas through the marls, and cried loudly for help to his fellow at the mouth of the shaft. While he was being hauled up he was stifled by oppression of the lungs, and fell lifeless to the bottom. Should any luckless wight approach the lagoon too

closely, he would stand the chance of sinking into a quagmire or losing a leg. Sheep occasionally fell victims when rushing too carelessly along, and after remaining a short time in the water, nothing but a bleached skeleton remained. Though this picture is perhaps rather overdrawn, the temperature being very considerably above the boiling point of pure water, very serious and generally fatal accidents must have resulted. It would be untrue to say that the *soffioni* were utterly useless. The skilled peasants would cleverly manage to roast their chest-nuts in sacks placed over these vapor vents; no small convenience in a country where this article is a substitute for bread. Birds, game, and cattle make the *lagoni* their winter resort, in order to escape from the cold, snowy ground. The latter, indeed, occasionally frequented the neighborhood to rid themselves of gadflies and mosquitoes.

Our traveler traced the vapors principally along the course of the rivulet, where they found their way out from beneath huge masses of rock. In their vicinity a hole made with a stick would frequently originate a little pool, or *lagoncello*, from whence sulphurous vapors poured forth. As to the noxious vapors, which are nothing but carbonic acid gas, he was told that the introduction of a copious supply of water into the vents destroyed their power. \* \* \*

In 1777, Hæffer, the chemist of the Grand Duke of Tuscany, found boracic acid at Monte Rotondo and Castelnovo; a fact confirmed two years subsequently at Monte Rotondo by Professor Mascagni, well known for his researches on the lymphatic system.

Gazzeri made some attempts to utilize the boracic acid in these waters in 1808, and again in 1816. Hæffer and Mascagni proposed to make borax from them—the latter in 1812. Mascagni, however, was too much engaged in his scientific labors to carry out this idea, for which he even obtained a patent during Napoleon's rule in Italy. He therefore ceded his right to Fossi, to whom he communicated his proposition for placing cauldrons of the solution of the acid in the lagoons, as in a water bath, in order to concentrate it.

Fossi was the first to obtain boracic acid in any quantity from Monte Rotondo, and I find from the *Atti dei Georgo filii*, tome xvii, Firenze, 1839, that he exhibited white glass in Florence as early as 1818, prepared from borax made from the lagoons.

Messrs. Gazzeri and Brouzet worked the lagoons of Monte Rotondo from 1815 to 1818, employing as their engineer Signor Ciaschi, who made further improvements by constructing artificial lagoons around the dry *soffioni*, to utilize the hitherto waste vapors. The poor fellow was one day superintending an operation of this nature, in 1816, when he fell into a fissure. He was dragged out half dead, and only lingered for a few days, during which time he suffered the most excruciating torture from violent spasms and frightful burns.

Gazzeri and Brouzet, with great difficulty, managed to export to France three tons and five and a half cwt. of very impure crude boracic acid in the nine and a half months ending April 1, 1818. \* \* \* Thus, for forty years, little or nothing was done, when in 1818, M. Francois Lardarel, a French gentleman then staying in Tuscany, resolved on the formation of a small establishment for the collection and extraction of the boracic acid. For many years his labors were attended with small success; the sale of the acid was steady, but the profits were inconsiderable. He was thus induced to study a more economical means of evaporation; the expense of fire-wood for that purpose, up to 1827, having swallowed up the greater part of his proceeds, the more so, as it was particularly scarce in that neighborhood, where not a blade of grass was to be seen, and road communication for bringing it had all to be made by the proprietor of the works.

After much thought, the brilliant idea struck M. Lardarel, that by some method he might take advantage of the natural steam jets or *soffioni*, arising so plentifully from the soil, and at the period I have mentioned he devised the means of imprisoning them and turning them to account, which I shall describe. The process was a triumph for those days, when, let us remember, steam was little known as an element in manufacturing industry. From that moment, the produce of the works rapidly increased, and the uses to which the boracic acid was applied became equally numerous.

At the present time there are no less than nine separate establishments belonging to Count Lardarel, all situated within a few miles of Castelnovo (Leghorn), a little town between Volterra and Massa Marittima, viz.: Lustignano, Lardarello, Lago, Saso, Monte Rotondo, Serrazzano, San Federigo, San Edoardo, and Castelnovo.

M. Duval has one establishment at the Lake of Monte Rotondo, and a new company has been established at Travale, near Volterra. All these places are in close proximity to eruptions of *Gabbro* or Miocene Serpentine.

\* \* \* \* \*

The works are so similar that it will only be necessary to describe in detail that of Lardarello, which is highly interesting. This thriving little colony is entirely the creation of Count Lardarel, and is situated on the torrent Possera, below the village of Monte Cerboli, three miles from Serrazzano and six from Pomarance. A group of half a dozen or more *lagoni* are seen on the slope of the hill about half a mile from the main road, from which they are completely hidden by rising ground. Some of these *lagoni* are those described by Targioni Tozzetti, but the vapor vents—the *soffioni* of which he speaks—no longer exist, as they have been artificially converted into *lagoni*.

Singularly enough boracic acid has never been found in the solid state at any depth to which search has been made, with the exception of such places in which it has sublimed. It is probably either the result of double decomposition of water and a volatile salt of boron; according to Dumas' theory sulphide of boron and water producing boracic acid and sulphuretted hydrogen, thus:  $\text{Bo S}_2 + 2 \text{HO} = \text{Bo O}_2 + 2 \text{HS}$ , or simply a chloride of boron and water producing



boracic and hydrochloric acids, thus:  $\text{Bo Cl}_2 + 2 \text{HO} = \text{Bo O}_2 + 2 \text{H Cl}$ . In support of which supposition we only find the boracic acid appear when there is water present, or it may be caused by the reaction of sulphuric acid on borates, such as tourmaline, the granite found not very far off being so rich in this mineral as to bear the name tourmaliferous granite. The theory I advance is tenable, provided we assume the heat to be very great. Though sulphuric acid is one of the most powerful and boracic acid the weakest, next to carbonic acid, at ordinary temperatures, they exhibit the reverse phenomena at very elevated temperatures; in fact, boracic acid, under such circumstances, will actually decompose sulphates formed by the action of sulphuric acid on borates. Before water is introduced into the fissures they are mere *soffioni*. Borates of the several bases are probably abundant at great depth and are uninjured by the continual passage of sulphurous vapors, and even sulphuric acid, on their way to the surface, whence the latter escape, but boracic acid is not to be detected. Water being now introduced lowers the temperature and the balance of affinities is altered, the powerfully corroding influence of the sulphuric acid on the borates is set in operation, whence the boracic acid is liberated and ascends in solution with the ejected water and steam.

The following is the analysis of the gases issuing from a *soffioni*, examined by Payen :

Carbonic acid	57.30
Nitrogen	34.81
Oxygen	6.57
Sulphuretted hydrogen	1.32
	100.00

Respecting the temperature of the fissures, none have satisfactorily treated the question, though it has attracted much attention from Pilla, Murchison, Lardarel, etc.

I think that some light is thrown on the subject by the presence of an instructive mineral round the lagoons, viz., anhydrite ( $\text{CaO}, \text{SO}_3$ ), evidently formed at a temperature at which water could not combine with the sulphate of lime to produce ordinary gypsum. When gypsum ( $\text{CaO}, \text{SO}_3 + 2\text{HO}$ ) is heated to  $260^\circ$  Fah. it loses its water of crystallization, and becomes plaster of Paris, but on cooling it absorbs the original quantity of water. When it is heated to redness this does not take place, but the mass melts into an enamel, which, according to Regnault, is identical with anhydrite. The heat on the other hand could not have been much above redness, provided my theory of borates is correct.

The first care of the manufacturer is the removal of a certain quantity of the clay and the formation of a *lagone*, or basin of more or less circular form, the sides of which have to be strengthened by rough stones to prevent them from falling in, the tenacity of the clay sufficing for the bottom. The usual depth of a *lagone* is from four to six feet, more rarely as many yards. The capacity and depth have to be regulated with the utmost care, according to the force of the vapor in that particular vent. During the period that the workmen are employed in digging a *lagone* the steam is conveyed away into the atmosphere above their heads by means of a tall chimney, which protects them from being scalded.

A stream of water has been brought to the uppermost lagoon at Lardarello, from near the Bagno del Morbo, not a quarter of a mile off. This lagoon is about fifteen or twenty yards in diameter, with a jet of steam in the center, forcing its way through the fissure by its specific gravity; the water comes in contact with the highly heated gases and rocks, and is immediately converted into steam, which, from its elasticity and enormous increase in volume, is ejected with great force, but is condensed as soon as it reaches the surface of the basin by the colder water around. This incessant vaporization of the water, and its subsequent liquefaction, produces a great commotion in the lagoon, a turbulent little fountain rising to the height of a foot, causing a succession of concentric ripples; all this time there is a copious discharge of sulphuretted hydrogen, which in one case I distinctly perceived in the night time full a quarter of a mile from a lagoon and before I knew of its existence there.

Having remained twenty-four hours subject to continual agitation, the water, which has become of a slate-blue color, is let out of the lagoon and passes into a canal, through which it is conducted into a second basin at a lower level; thence it passes through several more, each lower than the last, though of similar construction.

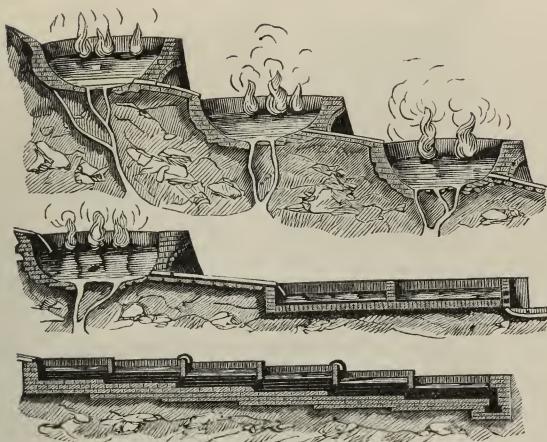


Fig. 16—Artificial Lagoons and Evaporators.—*Regnault's Elements of Chemistry.*

In this manner the water dissolves the boracic acid in the fissures, and brings it up mechanically mixed with it. No other object appears to be attained by making all the water pass through the chain of *lagoni*, than to obtain boracic acid of uniform density, though Dumas expressed to Count Lardarel the opinion that probably by some ingenious device, it might be brought to a saturation of fifteen to sixteen per cent—a great desideratum. The temperature of the liquid is considerably above  $212^{\circ}$  Fahr., and dense vapors rise for many yards above the ground, heating the air so much as to render it unpleasant to remain long near them. Efflorescent minerals and decomposed rock ejected by the steam, lie scattered all round the heated surface of the ground, along with sulphur incrustations, and many sulphates, such as gypsum, alum, and sulphate of ammonia, besides iron pyrites in minute veins in the fragments of rocks.

The water passes at stated intervals into the *vasco* (A, Fig. 17), a tank sixty feet square, which is covered by a tiled roof supported at the sides with slight brick pillars. Here the greater part of the mechanical impurities, clay, and the more insoluble sulphates, sink to the bottom, and the water regains its limpidity. The next operation is to concentrate the solution of acid, which is effected in the adjoining building containing the evaporating pans (B, Fig. 17).

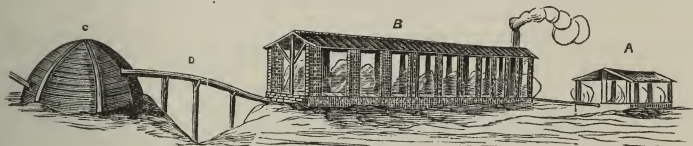


Fig. 17—Adrian Evaporators, Vasco, and Steam Dome—Jervis.

These are so exceedingly ingenious and simple as to merit particular consideration. Count Lardarel, who invented them, has given them the name of *Adrian Evaporators*. Three parallel series of shallow leaden divisions, called *Scanelli*, are placed in a line, each being a third of an inch below the one before it, from which it is only separated by a leaden partition half an inch broad and as deep. The *scanelli* are placed transversely, and are six feet long by twenty-two inches wide. They are arranged under a roof to keep off the rain, and the evaporation is not in any way impeded, since the sides are open, and only a few brick pillars of the lightest construction are employed to support the roof. The length of the building is often several hundred feet.

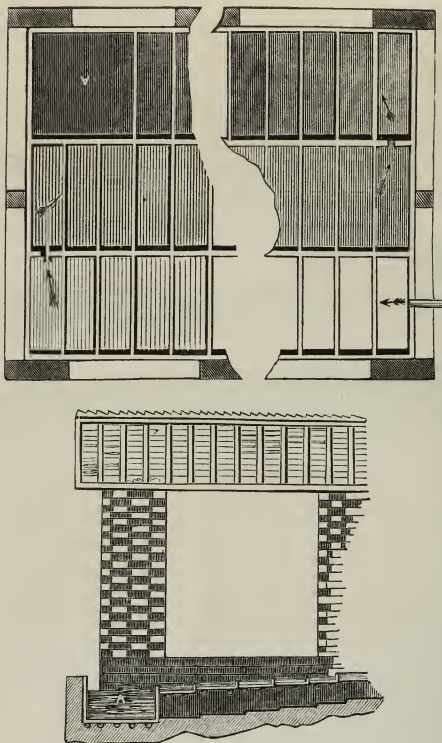


Fig. 18--Adrian Evaporator in plan and section—Jervis.

At the commencement of the operation a man turns a tap, which lets the water flow in regulated quantities from the *vasco* into the first *scanello*. Everything depending on this precaution, it now flows on from one division of these diaphragm pans to another, until arriving at the bottom of the building it passes along the second row of divisions, and finally back through the last series into the diagonal corner, where there is a deep reservoir, called the *Caldaja a sale* (A, Fig. 18). In its progress the water gradually evaporates, as mentioned before. It only contained one and a half to two per cent of boracic acid when it entered the building, but after having passed through fifty or sixty divisions, it assumes a decidedly yellow tinge, increasing in intensity until it becomes a bright golden yellow fluid, having a characteristic odor.

The interior arrangements of the evaporators, though they may appear simple enough, were the result of much thought. The leaden pans are supported by beams over a low vaulted steam passage, lined with hydraulic cement, to protect the stonework and to keep in the heat. For this purpose a *soffione* is vaulted over with a stone dome about ten feet high, firmly bound with wrought iron bars (C, Fig. 17). Water is admitted, and the imprisoned high pressure steam, thereby produced, acquires immense power, and thumping loudly against the dome, the jets of water seem ready at every moment to undermine the structure. The steam now passes through the vaulted passage into the lower chamber of the evaporators, and having traversed it from end to end, finds its way out into the open air through a chimney at the opposite end.

What formerly took sixty-two hours to evaporate is performed by this beautiful contrivance in twelve, the expense being also proportionably diminished.

From the *caldaja a sale* the syrup liquor is periodically conducted along a wooden pipe to the *bollajo*, or crystallizing house, in which a series of large barrels (tonne), three or three and a half feet in diameter, are arranged in a line.

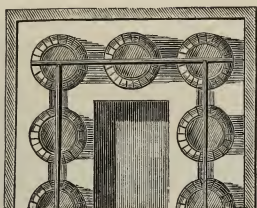


Fig. 19—Crystallizers.



When it is desired to fill them, all that is necessary to be done is to remove a plug placed over the center of each barrel, which runs round the building. The liquor remains four days in the barrels, during which time it has crystallized at the sides and bottom to the thickness of several inches. The liquid portion is then withdrawn by removing a plug, and finds its way along a longitudinal drain, by which means it is all saved for future use. No one could fail to admire these beautiful processes, whose characteristic merit is that they do not necessitate anything being lost.

The boracic acid crystallizes in hexagonal plates, about the size and thickness of a wafer, having a flaky appearance and pearly luster. From their form they naturally retain much water, mechanically mixed, so that they are first put in large wicker baskets (*Corbelli*) to drain, and then emptied on the floor of a large airy chamber, called the *Asciugatojo*, or drying house.

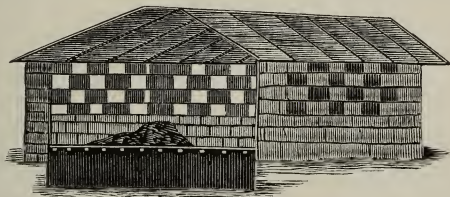


Fig. 20—Drying House.

The brick floor is heated like the evaporators, by steam passing through an underground chamber. The boracic acid being spread out in thin layers on the floor, is stirred from time to time with a wooden rake, and the crystals, while losing their sharp angles, separate in a great measure from each other. When dry, nothing remains to be done but to shovel up the mass of crystals and to remove them to the warehouse, where the produce of all the establishments is mixed, to insure its being all of uniform quality. It is then put in large barrels, containing 2,000 Tuscan pounds, or thirteen and a half cwt., and conveyed to Leghorn, whence the greater portion is exported to England. \* \* \*

The first impression produced on my mind after having gone through the whole establishment, was the marvelous simplicity of the successive processes. Almost everything being performed by Nature, little has to be effected by human agency but to convey the water to the *lagoni*, and to regulate the supply in the various operations; to empty the barrels and spread the crystals on the floor to dry. Such is the work allotted to the forty men who are employed at Lardarello on ordinary occasions. They commence at 4 A. M. in Summer, and at sunrise in Winter, and work on an average only four or five hours daily; thus I arrived at 10 A. M., but they had finished for the day. The art of producing boracic acid is, however, very harassing. Sometimes the sides of a lagoon break in, or there is not sufficient water; perhaps through carelessness on the part of the men the steam supply diminishes at a particular spot, as is liable to occur unless they regulate the quantity of water accordingly. The inevitable consequence is that the lagoon becomes useless, and the steam seeks an easier vent for itself elsewhere. In some cases it forms a new *soffione* a hundred yards off, or else, unable to force an immediate passage to the surface, it is needful to have recourse to boring, and a perfectly new lagoon is constructed. This operation is by no means an enviable task. The ground feels so hot near fissures which do not quite reach the surface, but from which the steam issues in minute jets, that I had my feet scorched through a very thick pair of shoes, and one is warned to retreat, since a few steps further on would probably cause one to sink into a hidden cauldron or steam bath. Around this place are fragments of *alberese* limestone, the gradual metamorphoses of which are very visible. First, the rock, which has a dirty brown discoloration, is shivered and rendered friable; and in other places actually converted into gypsum, as has been described by



Savi and Meneghini. Besides these, there are clays and marls of the Eocene, Miocene, and Pliocene formations. The boracic acid works of Lardarello are figured in the frontispiece.

The boracic acid crystals are far from being pure, containing a small quantity of numerous sulphates mechanically mixed. In 1842 *Wittstein* published the following analysis:

Crystallized boracic acid .....	76.494
Sulphate of iron .....	0.365
Sulphate of alumina .....	0.320
Sulphate of lime .....	1.018
Sulphate of magnesia .....	2.632
Sulphate of ammonia .....	8.508
Sulphate of soda .....	0.917
Sulphate of potash .....	0.369
Chloride of ammonium .....	0.298
Water of crystallization .....	6.557
Silicic acid .....	1.200
Sulphuric acid mixed with boracic acid .....	1.322
Organic matter and sulphate of iron .....	traces.
	100.000

The amount of foreign salts has considerably diminished since the *lagoni* were first made use of. In order to purify the crude product, which is not done in Tuscany, nothing further is necessary but to crystallize it once or twice.

The following letter from W. P. Jervis was received by the State Mineralogist in answer to one of inquiry. While it contains some repetitions of the foregoing quotation, it at the same time makes some corrections. It is given entire, for the reason that the connection would be broken if any portion was omitted:

TURIN, June 24, 1882.

MR. HENRY G. HANKS, *State Mineralogist of California, San Francisco*:

DEAR SIR: I have received your letter of May fourth. Only these last two or three days I returned from Rome. Now I inclose you the translation of the principal remarks I made on the geological origin of the boracic acid in the lagoons of central Italy, as contained in my great work "*I Tesori Sotterranei Dell Italia*," Vol. 2. You will perceive that since writing the "*Mineral Resources of Central Italy*" I have altered my opinion most fundamentally regarding the theories formerly held universally about the volcanic origin of these lagoons. I therefore request you, in perusing the volume in English alluded to, to bear in mind these new deductions. It is of material consequence, in order not to continue to regard these localities as connected with volcanic phenomena of which there is not only no proof, but direct evidence to the contrary.

As to the *technological* part, that is quite accurately described in the Mineral Resources, and the drawings and sections may be said to be just what I would now repeat.

In my book, the "*Guida alle acque minerali d'Italia*," a general view of the boracic acid lagoons of Lardarello and Pomerance is given with the domes, canals, etc.\*

Please not to misunderstand me. Boracic acid also exists in Italy in quiescent (not extinct) volcanoes at Vulcano in the Æolian Islands. (See "*Tesori Sotterranei*," volume 3, page 199.) It is quite a different thing from what is found in Tuscany, much as I thought originally it was all due to one cause. True, the association of minerals in both places is very remarkably similar. Probably the boracic acid of California has more analogy with that of Lipari (Vulcano) than with that of Pomerance and the neighborhood.

Boracic acid is produced in Central Italy on a vast scale in the territories of four attiguous communes, Pomerance, Castelnuevo di Val di Cecina, Massa Marittima, and Montieri. It is not extracted in the solid state, but, as is generally known, is brought to the surface through innumerable crevices, probably faults in the cretaceous and eocene rocks, being mechanically mixed with vapor of water at a high temperature and under great pressure, and artificially imprisoned by the condensation of the steam by means of cold water, whence it is brought into certain reservoirs of a more or less circular form, very shallow, lined with masonry consisting of fragments of limestone and coated with hydraulic lime, so as to resist, as well as possible, the corroding action of the acidulous liquid with which the stone comes in contact in these lagoons.

The first operation is to make bore holes in localities where the natural heat leads to the hope of finding the vapors.

Where the water penetrates into the internal fissures of the rock, a certain portion of boraciferous mineral is dissolved, the exact nature of which is not yet precisely ascertained, in spite of the splendid studies of Payen, Dumas, Bechi, Sainte-Claire-Daville, Leblanc, Fouqué, etc. Bechi considers that the boracic acid is due to the decomposition of some borate existing in the strata at great depths, by the agency of vapor. At first he suggested that it might be a nitride of boron, then a borate, probably a borate of lime. After the water of the boraciferous lagoons

\*See frontispiece.

has been for some time in contact with the steam into which it is converted, it is forced out of the fissures in the rock at the boiling point by its own pressure; this operation is repeated several times without any human agency, and when sufficiently enriched, the boiling contents of the lagoon are conducted to the shallow evaporating pans, made of sheet lead, termed *Adrian evaporators*, where the boracic acid is gradually concentrated to the point of saturation, when it crystallizes by a series of manipulations as simple in their application as they are elegant. The process will be found detailed in the author's *Guida alle acque minerali dell'Italia*, Provincia Centrale, vol. I, p. 116, Torino, 1868, to which the reader is referred, as well as to the author's *Tesori Sotterranei dell'Italia*, vol. II, pp. 427 to 432, and pp. 454 and 455, and to his *Mineral Resources of Central Italy*, published in English in 1868, and now getting rare.

Professors Fouqué and Gorceix give the composition of the gases emanating from the boracic acid lagoons, as follows:

Nature of the Gases in 100 parts.	Vapor Emanations of—		
	Lardarello.	Serrazzano.	Sasso.
Carbonic acid gas -----	90.47	87.90	88.33
Hydrosulphurous acid gas -----	4.20	6.10	5.43
Marsh gas -----	2.00	0.97	2.55
Nitrogen -----	1.90	2.93	1.55
Hydrogen -----	1.43	2.10	2.01
Oxygen -----			0.13

Professor Schmidt, of Dorpat, found the muddy deposit of the lagoons to contain gypsum (sulphate of lime), sulphate of ammonia, sulphate of magnesia, hyposulphate of ammonia, and small quantities of sulphate of potash and soda, besides very small proportions of carbonate of ammonia and sulphide of ammonium, together with fragments of undecomposed rock, the whole colored by sulphide of iron.

Professor Monoghini, in his beautiful monograph on boracic acid, observes that the lagoons of Serrazzano are in the immediate proximity of serpentine rocks, which he considers, in common with the greater part of geologists, as *eruptive*. He considers that the subterranean emanations come to the surface at the line of contact of the serpentine rocks and the molasse and shelly limestone, belonging, both of them, to the Miocene period. For my own part, I have absolutely renounced my former belief in the eruptive nature of serpentine and allied rocks, so leaving the explanation of this point to more able minds than my own. This being certainly no easy problem to solve, I will only say that as I hold the more recent views of Gastaldi, Gerlach, Sterry Hunt, and other geologists, I conceive there must exist here a center of immense activity of chemical decomposition, the center of which is probably connected with the serpentine rocks of prepaleozoic age, in the presence of water. The importance of these phenomena is such as to be surpassed alone in their whole, by volcanic phenomena alone, and therefore it is not to be wondered at they have always excited the interest of the greatest of men of science, though they afford a further ample field for useful research to future investigators. The boracic acid itself, whatever be the state in which it exists in the rock, seems to be contained in some soluble combination in the Tertiary, or at most in the Cretaceous sedimentary rocks.

I have the firm conviction that *volcanic phenomena of all kinds, as well as earthquakes of volcanic origin, are absolutely extraneous to the boracic acid lagoons of Central Italy*, never having heard of a single plausible argument in their favor, after a more accurate examination of the neighborhood than I could make the first time I visited it, and as given in my *Mineral Resources of Central Italy*.

This does not, however, exclude the probability of faults according to certain directions as first suggested by Murchison, to have been due to very ancient earthquakes, and affording the means for the passage of boracic acid and vapor of water. (†)

Laying aside the volcanic origin of the boracic acid lagoons, of which I wrote in my *Mineral Resources of Central Italy*, and which I wrote in deference to the celebrated chemists and geologists who had preceded me, but which I now consider to be far from correct, the reader will find in the little volume mentioned a very detailed technological and historical account of the boracic acid lagoons of Italy, as well as statements of the annual production up to 1859. Since that time it has been absolutely impossible for any one to get statistical statements of the quantity of boracic acid produced, but I believe it may be taken as being about equal to what it used to be. The discovery of boracic acid in the United States for some time produced a considerable perturbation in the trade of Italian boracic acid, it is true, but the clear profits are so fabulously great, and the expenses so insignificant, that should the prices fall 60 or 70 per cent from what they used to be, in all probability that circumstance would have as its only consequence to diminish the profits but not to prevent the production from proceeding exactly as before.

(†) JERVIS I. *Tesori Sotterranei dell'Italia*, Torino, 1874, Vol. 2, pp. 454, and following, which see.

At the lago di Monte Rotondo, in the commune of Massa Marittima, Province of Grossetto, many celebrated geologists may have taken this natural depression for the crater of an extinct volcano; its *form*, indeed, would authorize such a possible conjecture, but nothing more, for the rocks around are entirely sedimentary, and either Cretaceous or Tertiary, as at Pomarance. By means of deep borings, the rock has been brought into communication with water from the surface, and which would rather seem to be converted into vapor by such means, than to be natural steam or hot vapor of water already existing in the rock itself. The steam, charged with infinitesimal proportions of boracic acid rises to the surface of the ground through the bored holes, under very considerable pressure.

It is stated that the expense of producing a ton of boracic acid of commerce, in the crystallized state, but not refined, is as follows:

Manual expenses.....	\$10 00
Packing and carriage.....	13 00
Administration.....	8 60
General expenses, repairs, etc.....	28 40
Taxes.....	13 00
Total.....	\$73 00

Boracic acid also exists in volcanic rocks. The chief place in Italy where it occurs in some quantity is in the crater of the semi-extinct volcano of Vulcano, in the island of the same name, one of the classical *Æolian* group, close to Lipari, in Sicily. General Nunzianti, who lately died, worked both boracic acid and sulphur, which deposit on the interior of the crater, and can be collected on a small scale. Alum works were also made at the outer base of the mountain. Little capital was spent on the undertaking, which seems to have been conducted with little skill. At all events, it was sold by the General to a manufacturer of chemical products in Glasgow, who began working it about the year 1873. The necessary reservoirs were made and something began to be done, when it would appear that the American boracic acid competed too powerfully, and the affair was left standing idle.

The following report is from the "Commercial Relations of the United States." Reports from the Consuls of the United States on the commerce, manufactures, etc., of their consular districts. No. 18. April, 1882. Published by the Department of State, according to Act of Congress.

#### THE PRODUCTION OF BORACIC ACID IN ITALY.

[Report by Consul RICE, of Leghorn.]

I have recently returned from a most interesting excursion in the Volterra and Pomarance districts of the province of Pisa, and spent a short time at the mineral water establishment called "Bagni a Morbo," situated in the center of the circle of springs yielding boracic acid, the property of Count de Larderel; and, while there, had ample opportunity to examine and study the same. I have considered the subject worthy of report, inasmuch as boracic acid is largely exported to the United States from Leghorn.

The nearest of the boracic acid springs to Morbo (which establishment is also the property of the de Larderel family) is called "Lardarello;" the springs in and around the village so named, and about forty in number, besides which, others exist which are not worked.

Lardarello is the most important of the seven "borax villages" (if I may so term them), which are respectively named Lardarello, Sasso, Lago di Monte Rotondo, Lusignano, and Serrazano. The technical direction is here, as also the mansion of the Larderel family; the church, theater, schools, warehouses, stores, etc.; in fact, Lardarello is a model village, and apart from the scientific and commercial importance of the locality, is worthy of a visit simply as a specimen of what an intelligent and generous employer of labor can do, if so disposed, for the comfort of his laborers.

The properties of the springs, called on the spot "lagoni" or lagoons, were first discovered by two chemists attached to the Tuscan Grand Ducal Court, named Pietra Hœffer and Paolo Mascagni, in the year 1777; but the springs do not appear to have been effectually worked till early in the present century.

About the year 1824, Count de Larderel (grandfather of the present generation of proprietors) associated with a Frenchman named Lamotte, and commenced working, evaporating the water which rose with the acid, and crystallizing the remainder by means of wood fires, and this process continued till the sparsely wooded hills in the neighborhood were left bare of timber, and then the enterprise was nigh falling into neglect. It is said that accident alone, some thirty to thirty-five years since, decided Count de Larderel, then become sole proprietor, to utilize the hot steam issuing from the hot springs themselves to vaporize the water and crystallize the borax, and the system then introduced maintains its sway at the present time.

It would appear that the whole of this neighborhood contains most extensive borax deposits, and though nature allows the vapor to find its way through the natural fissures in the soil, it is by no means from such natural issues that the most abundant supply is obtained. Experience has shown that by the judicious use of artesian wells a far greater result is obtained.

The system followed is this: A shallow pond is dug, and in it an artesian well is bored, which at a small depth invariably strikes the vein of borax; not content with vapor alone, the boring is carried down till the well gives water; the boring machinery is then withdrawn, and water let into the pond; the upshoot of the boring heats this pond to boiling point in a few minutes, and the boiling in a very short time impregnates the water in the pond with boracic acid shot up with hot water from the artesian well; there only remains to draw off the water, which is done every twenty-four hours, and evaporate it. This process is effected by passing it over a series of shallow metal pans arranged as a cascade; the fall from one pan to another may be two to three inches, and the pans are fifteen to twenty in number.

Underneath the pans are a series of hot steam pipes, which keep the shallow pans at an intense degree of heat, the consequence being that a very large portion of the liquid which reaches the last or bottom pan is semi-solid boracic acid; this is then pumped into vats and allowed to cool, and when cold the vats have the appearance of being frozen over with a thick skin of very dirty and rotten ice; this skin is removed and strewn on the floor of a drying house heated by hot pipes under the floor, and by this means the acid becomes crystallized.

The boracic acid is then ready for packing; the color being the same in all cases, varying from a dirty white to almost black; the acid is mixed in the stores and packed in huge casks, weighing 14 to 16 cwt., for exportation.

The lagoons are most interesting to watch. When full of water the boiling is continuous, rising (especially in the case of the artesian borings) to some feet in height. When natural springs, the bubbles are about a foot above the level of the water; the vapor is, however, most clammy, and especially unpleasant from its excessive sulphurous odor.

When the water is pumped out, the bottom of the lagoon remains of a dirty mud color, with round, semi-spherical holes like pock-marks, varying from a foot to several feet in diameter and depth; these are the springs. When empty they each give off a small amount of vapor, but as water finds its way into the holes in question, ebullition commences, and each hole appears to be a cooking pot, boiling with all its might, the water rising more and more, the lagoon one huge boiling caldron.

The difficulty in the production, and a very grave difficulty it is, consists in the scarcity of water; in fact, in the Summer Lardarello is almost the only establishment that can work satisfactorily, and even at Lardarello the works are often working half time only. The water which has served in the mineral baths at Morbo is carefully drained down to the Lardarello reservoir, and there stored.

When I visited the place, after a long and particularly hot Summer, water for the works had become a precious thing. The residents, of course, get used to it, but visitors to Lardarello find any lengthy stay there unpleasant in the extreme, from the enormous quantity of moisture and vapor permanently suspended in the atmosphere, as also the oppressive smell of sulphur. The effect of this on metals may well be imagined. I happened to see in the music-room a strange looking musical wind instrument of a novel form to me, it being black and covered with a greasy coating a millimeter thick. I concluded it was an antique, and was amazed when I learned that it was a recent present from Count Lardarel to the band, and that what I saw was simply the normal state of all brass instruments there. The chemist's silver watch looked more like platinum than silver, and the chemist told me that only good gold of the purest quality kept its color.

Matters have been so arranged by the Lardarel family that their work-people, save for alimentary substances and raw materials, are almost independent of the outer world. The men and boys work on the borax, and the female portion of the community spin and weave. I visited a building containing some thirty looms, and the stuffs manufactured were really very fair in quality; the workers are paid by the piece, and the whole is put into store, the entire population drawing their textile fabrics thence at moderate prices. There is a doctor, a resident chemist, priest, schoolmaster and mistress, a bandmaster, etc. In case of illness the workman is sent at Count Lardarel's expense to Morbo, or other thermal establishment, as may be necessary, without losing pay. The houses are neat, airy, and commodious. The church is worthy of a larger village; in it I found a pulpit and altar, frontal in bronze, which Count de Lardarel purchased at the English exhibition in 1851.

I understand that the health of the people is excellent as a rule, and I was interested in hearing one of the head workmen, speaking of their contented life, saying, "We pray to God for the Lardarel family first, and for ourselves afterwards." How many employers of labor in the world have had that said of them?

My remarks have been confined to Lardarello, the other stations being but Lardarello on a smaller scale.

It would be most difficult to estimate with any degree of certainty the quality of borax produced, as all are reticent in the extreme on this point. From what I could glean, going from one source to another, I gathered that Lardarello averages three to three and a half tons per day, and that this station produces nearly one half of the whole quantity extracted, which would make some eleven tons per diem as the total production.

At Leghorn I have been unable to control these figures; the exports to other countries I have been unable to ascertain with precision. To the United States, 1,240,746 kilograms—value, \$211,061 85—was exported in 1880. This would be about one third of the whole amount produced.

During the first three quarters of 1881, there was a heavy falling off, which I have noted in former reports, exports to the United States amounting only to 65,648 kilograms; value, \$14,098 51.



The laborers on the Larderel property numbered one thousand eight hundred persons, of whom eight hundred males are employed in the acid production.

I may add here a few words regarding the baths of Morbo, used by the famous "Lorenzo il Magnifico," celebrated in Tuscan history; they contain springs hot and cold, comprising the properties of the mineral waters of Vichy, Montecatini, Casciana, etc. I saw myself persons suffering from chronic rheumatism *carried* into the establishment like children in arms, who, after a three or four weeks' cure, walked away with the elastic step of youth.

It is to be regretted that the present proprietor does not fit up the establishment for the reception of invalids, as its sulphur and iron springs are far superior to any in Italy, and equal to any in Europe.

WILLIAM T. RICE, Consul.

UNITED STATES CONSULATE,  
LEGHORN, ITALY, March 13, 1882.

Boracic acid is found in a free state in the waters of the lake of Monte Rotondo, in Italy, which lies near the lagoons before described. The waters contain one part of crystallizable boracic acid in five hundred, which is recovered by evaporation. The area of the lake is about eighteen acres. M. Duval, by whom the lake is worked, extracted sixty-four tons in 1854 and one hundred and forty-two tons in 1855. The following is the result of two analyses of crude Italian boracic acid by Professor Luca, as published in the report on the mineral resources of Central Italy by W. P. Jervis:

	No. 1.	No. 2.
Anhydrous boracic acid	50.7	46.6
Water	36.9	40.4
Sulphuric acid	9.1	9.5
Chlorine	0.2	0.1
Silica	1.0	1.2
Magnesia	1.1	1.3
Lime	0.5	0.6
Ammonia	0.3	0.4
Potash, soda, alumina, oxide of iron, and organic matter	trace	trace
	99.8	100.1
Impurity in the above	12.2	13.1
Crystalline boracic acid in one hundred parts	89.0	84.3

PRODUCTION OF BORACIC ACID AT THE WORKS OF COUNT LARDAREL, IN  
TUSCANY, FROM 1818 TO 1859, INCLUSIVE. (JERVIS.)

YEARS.	No. of Years.	Tons.	Cwt.	Pounds.
1818 to 1828	10	521	16	1,168,832
1828 to 1838	10	4,870	6	10,909,472
1839	1	748	13	1,676,976
1840	1	878	13	1,968,176
1841	1	886	6	1,985,312
1841 to 1845	4	3,695	2	8,277,024
1845 to 1850	5	5,218	5	11,688,880
1851	1	1,140	00	2,553,600
1852	1	1,156	19	2,591,568
1853	1	1,208	19	2,708,048
1854	1	1,319	7	2,955,344
1855	1	1,332	19	2,985,808
1856	1	1,427	1	3,196,592
1857	1	1,711	4	3,833,088
1858	1	2,026	10	4,539,360
1859	1	1,830	18	4,101,216
Totals	41	29,972	18	67,139,296

In 1861, more than 1,800 tons.

## UNITED STATES.

[Senate Misc. Doc. No. 46, 49th Congress, 1st Session.]

## IMPORTS AND DUTIES—1867 TO 1878. No. 110—ACIDS: BORACIC.

Fiscal year ending June 30	Quantity—Pounds.	Value	Rate of duty	Amount of duty received	Additional and dis- criminating duty	Average value per unit of quantity	Average duty re- duced to ad valo- rem—Per cent.
1867	770,756	\$73,396 00	5 cts. per pound.	\$38,537 80		.095	52.51
1868	243,993	22,845 00	5 cts. per pound.	12,199 65		.092	53.40
1869	998,033	109,974 00	5 cts. per pound.	49,401 65		.110	44.92
1870	1,166,145	173,806 00	5 cts. per pound.	58,307 25		.148	33.55
1871	1,204,049	185,477 00	5 cts. per pound.	60,202 45		.154	32.46
1872	1,103,974	191,575 00	5 cts. per pound.	55,198 70		.171	28.81
1873	1,222,006	255,186 00	Free of duty.			.208	Free.
1874	233,955	52,752 00	Free of duty.			.226	Free.
1875	41,742	6,280 00	Free of duty.			.150	Free.
1876	137,518	15,711 00	Free of duty.			.114	Free.
1877	107,468	11,231 00	Free of duty.			.105	Free.
1878	178,798	14,925 00	Free of duty.			.085	Free.

Boracic acid was placed on the free list June 6, 1872, and has been exempt from duties until recently. The duties at present, by late Acts of Congress, are as follows:

Refined borax	5 cents
Pure boracic acid	5 cents
Commercial borax	4 cents
Borate of lime	3 cents
Crude borax	3 cents

## IMPORTS AND DUTIES—BORAX AND BORACIC ACID.

[Reports of U. S. Custom House.]

## IMPORTS AND DUTIES—1867 TO 1878.—No. 168.—BORAX, CRUDE OR TINCAL.

Fiscal year ending June 30	Quantity—Pounds.	Value	Rate of duty	Amount of duty re- ceived	Additional and dis- criminating duty	Average value per unit of quantity	Average duty re- duced to ad valo- rem—Per cent.
1867	5,672	\$711 00	5 cts. per pound	\$283 60		.126	40.00
1868	22,293	2,985 00	5 cts. per pound	1,114 65		.132	37.50
1869	54,822	8,011 33	5 cts. per pound	2,741 10		.150	34.25
1870	2,616	322 00	5 cts. per pound	130 80		.125	40.62
1871	5	1 00	5 cts. per pound	25		.200	25.00
1872							
1873							
1874	588	78 00	Free of duty.			.132	Free.
1875							
1876							
1877	55	12 00				.219	
1878	286	61 00				.213	

## REPORT OF THE STATE MINERALOGIST.

## No. 169.—BORAX, REFINED.

Fiscal year ending June 30-----	Quantity—Pounds.	Value -----	Rate of duty-----	Amount of duty re- ceived-----	Additional and dis- criminating duty-	Average value per unit of quantity-	Average duty re- duced to ad valo- rem—Per cent--
1867-----	49,652	\$6,601 50	10 cts. per pound	\$4,965 20	-----	.132	75.21
1868-----	79,183	10,127 00	10 cts. per pound	7,918 30	-----	.127	78.1
1869-----	89,695	12,799 00	10 cts. per pound	8,969 50	-----	.142	70.0
1870-----	97,078	14,511 28	10 cts. per pound	9,707 80	-----	.151	66.9
1871-----	134,927	20,705 24	10 cts. per pound	13,492 70	-----	.153	65.1
1872-----	35,542	6,288 00	10 cts. per pound	3,554 20	-----	.176	56.52
1873-----	9,284	2,152 00	10 cts. per pound	928 40	\$22 40	.231	43.14
1874-----	3,860	1,253 00	10 cts. per pound	386 00	-----	.324	30.80
1875-----	5,153	1,224 15	10 cts. per pound	515 30	-----	.237	42.09
1876-----	3,145	691 35	10 cts. per pound	314 50	-----	.220	45.49
1877-----	3,500	676 10	10 cts. per pound	350 00	-----	.193	51.77
1878-----	3,492	514 00	10 cts. per pound	349 20	-----	.147	67.93

## No. 275.—LIME, BORATE OF.

Fiscal year ending June 30-----	Quantity—Pounds.	Value -----	Rate of duty-----	Amount of duty re- ceived-----	Additional and dis- criminating duty-	Average value per unit of quantity-	Average duty re- duced to ad valo- rem—Per cent--
1867-----							
1868-----							
1869-----							
1870-----	33,529	\$1,666 00	5 cts. per pound	\$1,676 45	\$64 30	.049	100.63
1871-----	45,600	2,248 00	5 cts. per pound	2,280 00	-----	.047	101.50
1872-----	22,500	800 00	5 cts. per pound	1,125 00	-----	.035	140.62
1873-----							
1874-----							
1875-----							
1876-----							
1877-----							
1878-----							

## No. 26.—IMPORTED MERCHANDISE ENTERED FOR CONSUMPTION, ETC., DURING THE YEAR ENDING JUNE 30, 1881.

ARTICLES.	Withdrawals from Warehouse, and entries for imme- diate consumption.	Quantities. (Pounds.)	Values.	Discriminating duty.
<i>Free of duty.</i>				
Boric acid-----	Immediate-----	187,053	\$15,771 00	-----

No. 26.—IMPORTED MERCHANDISE ENTERED FOR CONSUMPTION, ETC., DURING THE YEAR ENDING JUNE 30, 1881.

ARTICLES.	Withdrawals from Warehouse, and entries for Immediate Consumption.	Quantities. (Pounds.)	Values.	Rates of Duty.			Average value per unit of quantity.	Average ad valorem rate of duty—per cent.
				Quantities. (Pounds.)	Values.	Duty.		
						Ordinary.	Additional and discriminating.	Total.
<i>Dutiable.</i>								
Borax, refined.....	Immediate.	4,136	\$865 50	10 cts. per pound.	\$413 60	-----	\$413 60	47.79

No. 30.—IMPORTED MERCHANDISE ENTERED FOR CONSUMPTION, ETC., DURING THE FISCAL YEARS ENDING JUNE 30, 1879, 1880, AND 1881.

ARTICLES.	Year ending June 30, 1879.			Year ending June 30, 1880.			Year ending June 30, 1881.		
	Quantities. (Pounds.)	Values.	Discriminating duty.	Quantities. (Pounds.)	Values.	Discriminating duty.	Quantities. (Pounds.)	Values.	Discriminating duty.
<i>Free of Duty.</i>									
Boracic acid.....	306,462	\$21,888 00	-----	243,733	\$18,473 00	-----	187,053	\$15,771 00	-----
Borate of lime.....	-----	-----	-----	22,122	742 00	-----	-----	-----	-----

No. 30.—IMPORTED MERCHANDISE ENTERED FOR CONSUMPTION, ETC., DURING THE FISCAL YEARS ENDING JUNE 30, 1879, 1880, AND 1881.

ARTICLES.	Rates of Duty.	Year ending June 30, 1879.			Year ending June 30, 1880.			Year ending June 30, 1881.		
		Quantities. (Pounds.)	Values.	Duties.	Quantities. (Pounds.)	Values.	Duties.	Quantities. (Pounds.)	Values.	Duties.
<i>Dutiable.</i>										
Borax, refined.....	10 cts. per pound.	3,472	\$490 00	\$347 20	15,278	\$2,011 00	\$1,527 80	4,136	\$865 50	\$413 60



## REPORT OF THE STATE MINERALOGIST.

YEAR ENDING JUNE 30, 1880.

Boracic Acid—Free.		Borax, refined—10 Cents per Pound.	
Quantity—(Pounds).	Value.	Quantity—(Pounds).	Value.
63,756	\$4,368 00	9,489	\$884 00
23,015	1,741 00	1,232	213 00
106,123	7,806 00	4,367	866 00
48,557	4,294 00	-----	-----
241,451	\$18,209 00	15,088	\$1,963 00

YEAR ENDING JUNE 30, 1881.

Boracic Acid—Free.		Borax, refined—10 Cents per Pound.	
Quantity—(Pounds).	Value.	Quantity—(Pounds).	Value.
93,077	\$6,207 00	1,568	\$351 00
22,900	1,832 00	1,224	275 00
69,029	7,375 00	560	127 00
185,006	\$15,414 00	3,352	\$753 00

FISCAL YEAR ENDING JUNE 30, 1882.

Boracic Acid—Free.		Borax, refined—10 Cents per Pound.	
Quantity—(Pounds).	Value.	Quantity—(Pounds).	Value.
68,644	\$9,647 00	3,450	\$848 00
190,902	20,821 00	1,796	374 00
141,811	22,211 00	3,514	1,363 00
128,146	17,400 00	1,904	477 00
529,503	\$70,079 00	10,664	\$3,062 00

The following tables show the various duties imposed by our laws since 1842 :

	1842.	1846.	1857.	1861.	1867 to 1872.	1873 to 1883.
Boracic acid-----	5 per ct.	20 per ct.	4 per ct.	10 per ct.	5 cts. per lb.	Free.

	1842.	1846.	1857.	1861.	1867 to 1883.
Refined borax-----	Free.	25 per ct.	30 per ct.	3 cts. per lb.	10 cts. per lb.

	1842	1846.	1857.	1861 to 1867.	1867 to 1883.
Borate of lime .....	25 per ct.	20 per ct.	12 per ct.	10 cts. per lb.	Free.

	1842.	1846.	1857.	1861.	1867 to 1873.	1875 to 1883.
Tincal (crude).....	25 per ct.	25 per ct.	4 per ct.	Free.	5 cts. per lb.	Free.

#### CONSUMPTION, IMPORTATION, AND PRODUCTION OF BORAX AND BORACIC ACID.

It is impossible to estimate the cost of production of borax in California and Nevada, for the reason that the producers decline to give the information, but it may be assumed that with few exceptions it has not proved a remunerative business, for the reasons stated elsewhere.

Before March, 1873, the Legislature of Nevada passed a law taxing the proceeds of borax and soda mines.

For the quarter ending March, 1873, three companies reported, as follows:

##### A. M. HEARN:

Gross proceeds.....	\$12,318 00
Total expenses.....	8,785 00
Net profits.....	\$3,533 00

Or about \$154 per ton.

##### MOSHEIMER & ENGELKE:

Net profits on ten tons, \$210, or \$21 per ton.

##### PACIFIC BORAX COMPANY:

Net profits on 113 tons, \$1,737; about \$15 per ton.

In 1866 the consumption of borax in Great Britain was estimated by Ross Brown at 11,000 tons. Seventy-five tons of borax are consumed on the Pacific Coast.

Charles Pfeiser, of New York, estimates the consumption of boracic acid in the United States as follows, all of which is imported:

Manufacture of borax .....	2,000,000 pounds
Preserving meat.....	300,000 pounds
Manufacture of glass and pottery.....	300,000 pounds
Total .....	2,600,000 pounds

In 1882 the total consumption of borax in the United States was estimated at 1,600,000 pounds.

The Oil, Paint, and Drug Reporter of January 18, 1882, estimates the importation of boracic acid into New York for the year 1881 at 1,659,256 pounds.

The importations of boracic acid into New York for the ten months ending November 1, 1882, was 2,009,993 pounds.

The following examples of the imports of boracic acid into England are from Ure's dictionary—values calculated into dollars:

## REPORT OF THE STATE MINERALOGIST.

FOR THE YEAR 1855.

	Amount in pounds.	Value.
Sardinia .....	9,520	\$1,857 55
Tuscany .....	2,999,024	587,640 55
Gibraltar .....	106,064	20,782 25
Total .....	3,114,608	\$610,280 35

FOR THE YEAR 1856.

	Amount in pounds.	Value.
Sardinia .....	35,056	\$6,678 45
Tuscany .....	2,807,056	534,780 40
Peru .....	1,453	31,010 90
Other parts .....	112	19 40
Total .....	2,843,677	\$572,489 15

The following tables, showing the production of borax in the Pacific States, have been prepared with great care, and are as nearly correct as possible. The figures have been furnished by the producers themselves, or by those who have bought and sold their products:

## PRODUCTION OF BORAX OF THE PACIFIC STATES—IN POUNDS.

Year.	CALIFORNIA.		NEVADA.		Total.
	San Bernardino Borax Man'g Co.	Others.	Smith Bros.' Pacific Borax Co.	Others.	
1864 .....		24,304			24,304
1865 .....		251,092			251,092
1866 .....		401,632			401,632
1867 .....		439,824			439,824
1868 .....		64,513			64,513
1869 .....					
1870 .....					
1871 .....					
1872 .....		280,000			280,000
1873 .....	750,000	280,000		970,000	2,000,000
1874 .....	1,729,891	99,980	2,003,930	166,199	4,000,000
1875 .....	2,147,000	189,000	2,315,260	488,740	5,140,000
1876 .....	2,752,000	121,909	1,740,720	566,281	5,180,910
1877 .....	1,986,970		2,735,700	4,610	4,727,280
1878 .....	746,840		2,055,960		2,802,800
1879 .....	727,146		827,840		1,554,986
1880 .....	1,219,948		2,640,800		3,860,748
1881 .....	1,380,205		2,665,200		4,045,405
1882 .....	1,465,732		2,350,539	420,020	4,236,291
1883 .....	720,000	80,000	1,567,724	432,276	2,800,000
Totals*	15,625,732	2,232,254	20,903,673	3,048,126	41,809,785

\* To June 1, 1883.

## PRINCIPAL PRODUCERS OF BORAX ON THE PACIFIC COAST.

CALIFORNIA.	Amount, (lbs).	Total, (lbs).
California Borax Company -----	1,741,364	17,857,986
San Bernardino Borax Mining Company -----	15,625,732	
Dodge & Co. -----	254,209	
Others -----	236,681	
NEVADA.		
Smith Bros. -----	18,007,511	23,951,799
Pacific Borax Company -----	2,896,162	
Jos. Mosheimer -----	553,240	
Smith & Storey -----	501,910	
Teel's Marsh Borax Company -----	344,760	
English & Shaver -----	250,320	
Judson & Shepard -----	216,360	
J. M. Kane -----	66,120	
American Borax Company -----	46,900	
Johnson & Shaver -----	132,120	
A. J. Rhodes -----	29,280	
D. H. Dillard -----	21,120	
L. A. Engelke -----	18,980	
E. Griswold -----	7,000	
R. M. Johnson -----	6,720	
S. Austin -----	1,000	
Nevada Salt and Borax Company -----	82,300	
W. J. Houston -----	43,400	
Others -----	726,596	
		23,951,799
Grand total to June 1, 1883 -----		41,809,785

## SALES OF BORAX BY THE CALIFORNIA BORAX COMPANY.

1864 -----	24,304 lbs. -----	Shipped to New York
1865 -----	250,880 lbs. -----	Shipped to New York
1865 -----	212 lbs. -----	Sold in San Francisco
1866 -----	353,248 lbs. -----	Shipped to New York
1866 -----	48,384 lbs. -----	Sold in San Francisco
1867 -----	374,752 lbs. -----	Shipped to New York
1867 -----	65,072 lbs. -----	Sold in San Francisco
1868 -----	64,512 lbs. -----	Sold in San Francisco
Total -----	1,181,364 lbs.	

## RECAPITULATION.

Sold in New York -----	1,003,184 lbs
Sold in San Francisco -----	178,180 lbs
Total -----	1,181,364 lbs



## NEW YORK JOBBERS' PRICES OF BORAX, FROM 1864, TO MAY, 1883.

Showing the fluctuations caused by the production of California and Nevada Borax, in cents per pound.

	1864.	1865.	1866.	1867.	1868.	1869.	1870.	1871.	1872.	1873.
Highest price	Oct. - 50	Feb. - 44	Dec. - 35	Nov. - 37	Sept. - 38	40	Mar. - 35	July - 37	May - 38	Feb. - 38
Lowest price	Mar. - 28	Sept. - 31	July - 31	Mar. - 34	July - 34	40	Jan. - 34	Jan. - 32	Jan. - 33	Sept. - 25
	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.
Highest price	Feb. -	Nov. - 17	Mar. - 16	June - 14	Jan. - 12	11	Mar. - 12	15	May - 17	Apr. - 16
Lowest price	Dec. -	Jan. - 16	Nov. - 12	Dec. - 10	July - 7½	11	Jan. - 10	15	Jan. - 14	Jan. - 14

## NEW YORK JOBBERS' PRICES OF BORACIC ACID, FROM 1867, TO MAY, 1883.

Showing the fluctuations caused by the production of California and Nevada Borax, in cents per pound.\*

	1868.	1869.	1870.	1871.	1872.	1873.	1874.	1875.	1876.
Highest price	July - 85	85	85	85	85	85	Mar. - 80	77	77
Lowest price	June - 80	85	85	85	85	Apr. - 65	Feb. - 70	77	77
	1877.	1878.	1879.	1880.	1881.	1882.	1883.		
Highest price	Jan. - 77	Jan. - 55	Jan. - 45	37	37	37	37	37	37
Lowest price	Dec. - 62	Dec. - 45	Feb. - 37	to Dec. - 37	to Dec. - 37	to Dec. - 37	to Dec. - 37	to Dec. - 37	to Dec. - 37

\* The information used in the construction of this and the borax table was compiled from files of the Druggists' Circular, by Mr. James G. Steele, of San Francisco.

## BORAX MINERALS AND THOSE CONTAINING BORACIC ACID IN SMALL QUANTITIES.

### BORAX.

*Biborate of soda*, *native borax*, or *tincal*, has been described in the body of this work. The chemical and mineralogical characteristics are given below:

It has a sweetish taste and an alkaline reaction. It dissolves in twelve parts of cold water and in two parts of boiling water. At a low heat it melts in its water of its crystallization; if the heat be continued, it swells and becomes a white porous mass. At a red heat it fuses into a transparent fluid, which becomes, when cold, a transparent solid resembling glass. Fused with fluorspar and bisulphate of potash it colors the blowpipe flame distinctly green. Luster, vitreous; color, white, gray, brown, pinkish, greenish; generally translucent, sometimes transparent; brittle, streak white; phosphorescent if powdered in the dark.

The most beautiful transparent and perfect crystals form at the borax works in weak solutions, which have been allowed to stand for a considerable time undisturbed. The purest natural crystals are found on the property of the San Bernardino Borax Company, which are shoveled into the tanks by the ton. They differ from the celebrated crystals from Borax Lake, Lake County, in being transparent and inclosing fluid in large cavities.

### SASSOLITE.

*Native boracic acid* has been sufficiently described in the body of the work under the head of boracic acid.

### ULEXITE.

*Borate of Lime*, *Tiza*, *Boronatrocalcite*, *Natroborocalcite*, *Tinkatzit*, *Cotton Balls*, *Sheet Cotton*, etc.

ULEXITE is a natural hydrated borate of lime and soda. This curious mineral was first found in the nitre beds of Peru in small quantities, in small globular concretions, showing when broken interlaced, silky-white crystals; sometimes also inclosed crystals of salt or gypsum. It was first examined by Ulex. His analysis of a specimen from Iquique, Southern Peru, gave:

Boracic acid.....	49.5
Lime.....	15.9
Soda.....	8.8
Water.....	25.8
Total.....	100.0

The mineral was afterwards analyzed by A. A. Hayes, who proposed the formula ( $\text{CaO}$ ,  $2 \text{BO}_3 + 6\text{H}_2\text{O}$ ). He supposed the soda found by Ulex to result from mechanically mixed glauberite. For some time this mineral was called "Hayesene," but Dana, in the last edi-

tion of his work on mineralogy, gives it the name of Ulexite, in justice to the first observer.

The following extracts from "Mineraux du Pérou," by A. Raimondi, Paris, 1878, seem to show the analysis of Hayes to have been a mistake.

Ulexite was first found in the Province of Tarapaca, then named Borax or Tiza—lately found in the Cordillere de Maricunga, at an altitude of 3,800 meters (12,464 feet). Mr. Raimondi calls attention to a widespread error found in works on mineralogy, as to a borate of lime without soda, under the name of Hayesene, which, in his opinion, does not exist in Peru. In 1853, while in the employ of the Government of Peru, he visited all the known localities of the borates in the Province of Tarapaca. He examined a large number of specimens, and made a great number of excavations, and his conclusions were that the sample of borate of lime called Hayesene was Ulexite, or Boronatrocalcite. Ulexite was found for the first time in 1836-7, in Tarapaca, forty or fifty kilometers from Iquique, under the crust that covers the nitrate of soda beds, nearly always in little rounded masses from the size of a hazelnut up to that of a potato—color white, fibrous, and silky. Very often the balls of ulexite have in their interior a nucleus of glauberite. The first notice in the Scientific Press is found in the second edition of the mineralogy of Dana, 1844, page 243, in which the author says that he had received a communication from Mr. Hayes, descriptive of a new mineral, under the name of borate of lime (*borocalcius obliquus*). But in that description Mr. Hayes confounded borate of lime with glauber salt in a state of mixture:

I repeat here what I have already said, that I possess the most intimate conviction that the mineral described by Mr. Hayes as presenting rounded masses showing fibrous, white, silky crystals frequently accompanied by glauberite, is borate of lime and soda, and not simple borate of lime.

The many analyses which I made of all the specimens collected while Commissioner to the Government of Peru in 1853; the analysis made in 1855 by the distinguished chemist Rammelsberg, of the material which presented all the physical characters of the doubtful Hayesene, establishes in a manner nearly certain that in Peru there exists only a single combination of boric acid with lime, and that the combination is a double borate of lime and soda, described in works on mineralogy, under the name of ulexite or boronatrocalcite.

To complete what I have said on this important mineral, I give the composition of three specimens of boronatrocalcite found in a state of great purity in a very dry earth in the province of Tarapaca, which appear in the report which I presented to the Peruvian Government in 1854.

These results agree with those obtained by Rammelsberg, only the specimens analyzed by the latter were not pure, because the boronatrocalcite was mixed with a small quantity of chloride of sodium and sulphate of soda and lime.

ANALYSIS OF ULEXITE, OR BORONATROCALCITE.

Substance Found.	By A. Raimondi.			By Rammelsberg.
	(1)	(2)	(3)	
Boracic acid-----	42.98	43.13	43.04	42.12
Lime-----	13.94	14.14	14.06	12.46
Soda-----	6.96	6.92	7.05	6.52
Water-----	36.80	35.75	35.85	34.40
Chloride of potassium-----				1.26
Chloride of sodium-----	0.16	Traces.	Traces.	1.66
Sulphate of soda-----	0.12	Traces.	Traces.	0.81
Sulphate of lime-----				0.77
Total-----	100.96	99.94	100.00	100.00

Notwithstanding the fact that Mr. Raimondi failed to find hayesene there seems to be such a mineral, a *hydrous borate of lime, without soda*. Mr. N. H. Darton (American Journal of Science, 1882,) describes a mineral from Bergen Hill, New Jersey, to which he gives the name of Hayesene, which had the following composition:

Lime.....	18.39
Boracic acid.....	46.10
Water.....	35.46
Total.....	99.95
Soda, silica, and magnesia, traces.	

*Ulexite* is found at a number of localities on the Pacific Coast, some of which have been noticed elsewhere in this paper. It occurs in rounded concretions, from the size of peas to masses ten or twelve inches in diameter. Unless the so called cotton balls are carefully selected by hand the percentage is greatly reduced by the admixture of sand, worthless soluble salts and water. Much disappointment has been experienced from this cause. Shipments have rarely failed to be much lower grade than was expected.

As early as 1871, in the examination of *ulexite* and impure borates from the then newly discovered Columbus marsh borax fields, I accidentally discovered that very impure borate of lime in the cotton ball form could be concentrated and purified by very simple mechanical means, which information was given to the public in a report to the Nevada Consolidated Borax Company, November 11, 1871, in the following words:

Crude borate of lime can be easily and cheaply concentrated by simple mechanical treatment with cold water, in which it is nearly insoluble. A large vat should be constructed, in which the crude material is to be placed with a quantity of cold water. The contents of the vat must be kept in slow agitation by the proper machinery, until the borate of lime has been reduced to a pulpy form, and all mechanical impurity has settled to the bottom. When these conditions are fulfilled, a plug is withdrawn, and the contents of the tub allowed to run into a settling vat. Care must be taken not to allow the sand and other impurity to flow out with the purified borate of lime. In the settler the borate of lime will soon fall to the bottom, and the clear portion, which contains biborate of soda (if that salt was associated with the borate of lime), may be recovered by proper crystallization.

The purified *ulexite* may then be thrown on an inclined platform and allowed to drain, and then be dried in the sun.

The borate of lime so purified should have nearly the composition of the best natural product.

As borate of lime is quite voluminous in this condition, it should be compressed by powerful screws into a smaller bulk, as crude cotton is treated for the same reason. *Ulexite* containing twenty-four per cent of boracic acid has a market value in London of £18 per ton of 2,240 pounds.

There is a variety of *ulexite* called *sheet cotton* by the prospectors, which is sometimes quite overlooked. It is granular in appearance, but under the microscope it is seen to be *ulexite* in minute silky crystals. There is a specimen in the State Museum (No. 3590) which shows both varieties. Ten tons of boracic acid was made from this substance at the Phoenix Chemical Works at Columbus, Esmeralda County, Nevada, of which Mr. H. S. Durden was Superintendent. A sample of this acid (No. 3591) may also be seen in the State Museum. The following mechanical analyses of crude *ulexite* show the nature of the impurities:



## No. 1.

Sand .....	9.25
Water hygroscopic .....	21.00
Soluble salts, mostly sulphate of soda and salt .....	17.36
Borate of lime .....	52.39
	<hr/> 100.00

## No. 2.

Sand .....	trace.
Water .....	36.80
Soluble salts .....	11.04
Borate of lime .....	52.16
	<hr/> 100.00

## CRYPTOMORPHITE.

Cryptomorphite is a very rare mineral, found with glauber salt, only in Nova Scotia, at one locality. It is white, without luster, soft, in kernels the size of a pea. When a small portion is placed under the microscope and magnified 100 diameters, the mineral is seen to consist of rhombic plates, from which the name is derived, meaning hidden form.

## ANALYSIS BY HOWE.

Boracic acid .....	58.5
Lime .....	15.6
Soda .....	5.8
Water .....	20.1
	<hr/> 100.0

## PRICEITE.

In October, 1871, Lieutenant A. W. Chase brought to the Academy of Sciences of San Francisco a sample of chalky substance which he thought to be magnesia. A small sample was given to me for examination, which I turned over to a pupil, Mr. E. J. Shipman, who spent some time over it and reported it to be borate of lime. Never having seen borate of lime in this form, I requested him to repeat his experiments, which he did, and with the same result. I then made an examination of the mineral myself, both chemical and microscopical, which led me to class it with *cryptomorphite*. The appearance under the microscope was so characteristic that I had no doubt as to its identity. At the evening meeting, November sixth, Lieutenant Chase presented it to the Academy of Sciences. Subsequently two samples were analyzed by Thomas Price, of San Francisco, which gave the following result:

	1.	2.
Boracic acid .....	47.04	45.20
Lime .....	29.96	29.80
Water .....	22.75	25.00
Alkalies .....	.25	traces.
	<hr/> 100.00	<hr/> 100.00

In 1873, Professor Silliman made a study of this mineral, and obtained the following mean of three analyses:

Boracic acid	49.00
Lime	31.83
Water	18.29
Alumina, salt, and oxide of iron	.96
	<hr/> 100.08

The absence of soda separates this mineral from ulexite and cryptomorphite, and seems to make it a new species, named as above by Professor Silliman. After studying this mineral and examining many specimens, I am led to believe that it is changed from ulexite by the abstraction of the soda and part of the water. I have a specimen of colemanite which has undoubtedly changed from a ulexite cotton ball.

#### PANDERMITE

Is a variety of priceite. The following extracts from *The London Journal of the Society of Arts*, August 6, 1880, by C. C. Warnford Lock, affords all that is known relating to this mineral:

I have now to deal with a new commercial borate, which, on the score of geographical position, abundance, cheapness of working, and easy manipulation, is certainly destined in a great measure to rule the markets of Europe, and particularly of Great Britain.

The new field lies on the Tehinar-Sau, a small stream feeding the Rhyndacus River, whose outlet is in the Sea of Marmora, near the port of Panderma, on the Asiatic shore. It embraces the villages of Sultan-Tchahir, Yildiz, and Omerli, and the guard-house of the Demircapon pass. The area of the field is computed at over 13,000 acres (20 square miles). Its eastern confines nearly abut upon the Rhyndacus, which has been navigated by steamers up to a point called Balakeser. A company has been formed for deepening and improving the stream, and a railway has been projected from Panderma to Balakeser. The wagon road has hitherto been utilized for transporting the mineral, the distance from Panderma to the western edge of the field being about forty English miles. The port of Panderma is regularly frequented by local steamers, and offers every convenience for shipping.

The field is situated in a basin of tertiary age, surrounded by volcanic rocks, which vary from granite on the east to trachyte on the north, and columnar basalt on the west. Several basaltic hills and dikes protrude in different portions of the basin, and the presence of hot and mineral springs further testifies to the volcanic influences which have been at work, and in which, doubtless, originated the boracic mineral. The latter occurs in a stratum at the bottom of an enormous bed of gypsum, its greater specific gravity probably impelling it downwards while the whole mass was yet in a soft state. Several feet of clay cover the gypsum bed, which is here 60 to 70 feet thick, though in places it attains to double that thickness.

The boraciferous stratum varies in depth; it has been proved for a vertical distance of forty-five feet. The mineral exists in closely-packed nodules, of very irregular size and shape, and of all weights up to a ton. Von Rath has named it "Pandermite," from the port of shipment.

In outward appearance it closely resembles a snow-white, fine-grained marble. Chemically speaking, it is a hydrous borate of lime, its composition being expressed by the formula  $2\text{CaO}$ ,  $3\text{B}_2\text{O}_3$ ,  $3\text{H}_2\text{O}$ ; in other words, it consists of boracic acid 55.85 per cent; lime, 29.78 per cent, and water 14.36 per cent. Its richness in boracic acid is at once apparent, and places it high above the other commercial borates. Thus ordinary borax (borate of soda) contains only 36.58 per cent of the acid; boro-calcite and boronatro-calcite (borates of lime and of lime and soda) vary from  $8\frac{1}{2}$  per cent up to 46 per cent, and average about 40 per cent, boracite and stassfurtite (borates of magnesia), containing respectively about 63 per cent and  $60\frac{1}{2}$  per cent, alone surpass it in this respect, and they can hardly be deemed commercial minerals. After very simple preparation pandermite can be very directly applied as a flux, and is more economical than borax for this purpose, thanks to its larger proportion of boracic acid.

An outcrop of the mineral was discovered by a foreigner some years since, and the bed was secretly worked; small shipments were occasionally made to Europe under the denomination of plaster of Paris, thus keeping the matter hidden, and at the same time avoiding the payment of dues and duties. The Ottoman Government has since been apprised of these irregularities and has taken energetic measures to correct them. More recently it has granted a comprehensive concession to a party of British residents, who are setting to work to develop the property. The district enjoys the great advantage of being under British protection.

The workings were at first placed under that section of the *Réglement des Mines* relating to quarries, but have since been transferred to the section regulating mines proper. Steps are being taken to open up the deposit in a systematic manner, by first sinking a number of bore-holes—as has been done with the Kainit beds at Stassfurt—to ascertain the points of greatest development in the basin. The locality possesses a healthy climate, except in the Autumn, when there is some ague.

Labor is very cheap and abundant, Turks, Armenians, Greeks, Circassians, Tartars, and Italians being obtainable from the neighboring villages. There is a supply of water; oak and fir timber may be procured at six to seven miles distant, and scrub for fuel covers the surrounding hills.

The actual cost of the mineral, as now worked, is as follows:

Raising and dressing (exclusive of cost of tools).....	10.0 paras per oke
Transport to Panderma.....	9.0 paras per oke
Customs duty, 1 per cent ad valorem.....	.5 paras per oke
Management and other charges.....	2.5 paras per oke

Total.....	22.0 paras per oke
------------	--------------------

	£	s.	d.
At 795½ okes per ton, and 128½ piastres per £ sterling (1 piastre=40 paras) this will equal.....	3	8	3 per ton
To this must be added government royalty, 5 per cent ad valorem, say.....	0	5	0 per ton
Contingencies.....	0	10	0 per ton
Freight and insurance.....	0	15	0 per ton

Making a total cost, "c, f., and i.".....	£4	18	3 per ton
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The present values of the boracic products now in the market vary from £46 to £60 per ton, according to quality; the lowest figure ever reached here has been about £20 a ton, at which price the demand would immensely increase.

Pisani, of Paris, analyzed this mineral and obtained the following result:

Boracic acid.....	50.1
Lime.....	32.0
Water.....	17.9

100.0

It will be found stated elsewhere that the variety pandermite has recently been found in apparent abundance in Death Valley, Inyo County, and at Calico, San Bernardino County, and the cryptomorphic variety at the latter locality.

#### COLEMANITE

Is also a variety of priceite found recently in Death Valley. The following analysis was made by Thomas Price, of San Francisco, March, 1883, by whom the original priceite was first analyzed:

Anhydrous boracic acid.....	48.12
Lime.....	28.43
Water.....	22.20
Alumina and oxide of iron.....	.60
Silica.....	.65

100.00

In the analysis of colemanite, the alumina, iron, and silica are probably mechanical impurities—1.25 being added proportionately to the other constituents, gives the following percentage:

Boracic acid.....	48.72
Lime.....	28.79
Water.....	22.49

100.00

This gives the approximate formula  $4\text{Bo}_3, 3\text{CaO}, 6\text{HO}$ , which is the same obtained by Silliman for priceite, which no doubt it is in a crystalline state. As this mineral possesses certain physical properties differing from priceite, the name colemanite has been given to it

to distinguish it from the soft chalky mineral found both in southern Oregon and San Bernardino County, California.

The name *colemanite* was given by the discoverer of the mineral in honor of William T. Coleman, of San Francisco, who has been identified with the borax interests of the Pacific Coast from the commencement.

#### PROPERTIES OF COLEMANITE.

Color and streak white; milky to transparent; hardness 3.5—4; specific gravity, 2.39; before the blowpipe exfoliates, decrepitates violently, and melts imperfectly; after considerable heating it imparts a reddish yellow color to the flame, which changes to green. The mineral pulverizes easily, fragments obscurely rhombic. It is wholly soluble in hydrochloric acid with heat. From the solution boracic acid crystallizes on cooling. The filtrate gives a white precipitate with ammonia and oxalate of ammonia. With sulphuric acid, or with fluorspar and bisulphate of potash, tinges the blowpipe flame green. Luster of the mineral vitreous to adamantine. It shows no perfect crystals, but appears like semi-crystalline calcite.

#### BECHILITE

Is a borate of lime without soda, and therefore resembling priceite, found by Bechi, from whom it was named, as an incrustation, at the baths of the lagoons of Tuscany.

The following analysis is by Bechi:

Boracic acid	52.2
Lime	20.9
Water	26.9
	100.0

Very little is known about this mineral, which was found only in small quantities. It has physical properties resembling ulexite and priceite.

#### HOWLITE,

A silicious borate of lime, is found in small imbedded globules in gypsum at Brookville, Nova Scotia.

Analysis by How:

Silica	15.25
Boracic acid	44.22
Lime	28.69
Water	11.84
	100.00

This mineral is too rare to have any commercial value.

TABLE SHOWING THE SIMILARITY OF THE BORATE OF LIME MINERALS.

	Ulexite.	Cryptomor- phite.	Priceite.	Pandermite.	Colemanite.	Bechilite.	Howlite.
Boracic acid	43.04	58.50	49.00	55.85	48.72	52.20	44.22
Lime	14.06	15.60	31.83	29.78	28.79	20.90	28.69
Water	35.85	20.10	18.29	14.36	22.49	26.90	11.84
Soda	7.05	5.80					
Silica							15.25
	100.00	100.00	99.12	99.99	100.00	100.00	100.00



## RHODIZITE.

Rhodizite—named from a Greek word meaning resemblance to a rose, from the red color imparted to the blowpipe flame—is a very rare mineral, found only in minute crystals on red tourmaline at one locality in the Ural Mountains. These crystals are modified dodecahedrons, so small that sufficient cannot be obtained for analysis, for which reason its chemical character is uncertain. Dana considers it a lime boracite, while Gmelin describes it as a borate of lime. Before the blowpipe it fuses with difficulty to an opaque glass, tingeing the flame first green and then red.

## WARWICKITE

Is a borate and titanate of magnesia, with iron, alumina, and silica. The following analysis is by J. Lawrence Smith, who made a reëxamination of it in 1853:

Boracic acid .....	27.80
Titanic acid ( $TiO_2$ ) .....	23.82
Magnesia .....	36.80
Sesqui-oxide of iron .....	7.02
Alumina .....	2.21
Silica .....	1.00
	<hr/>
	98.65

Hardness, 3—4; specific gravity, 3.188; color, dark brown, sometimes copper red; fracture, uneven, brittle.

This is a very rare mineral, first described by Professor C. U. Shepard, and named from Warwick, New York, the first locality. It was first supposed to be a titanate of magnesia and iron. The presence of boracic acid was discovered by Smith. It is too rare to have any commercial value, but is interesting as showing that borax minerals may exist more plentifully than is generally supposed, and that it may be to their decomposition that free boracic acid and the soluble borates are due. It occurs in a granular limestone at the locality mentioned.

## LAGONITE.

Named from the lagoons of Tuscany, another rare mineral, is a borate of iron, found in earthy masses of yellow ochre, and is an incrustation at the Tuscan lagoons.

## ANALYSIS BY BECHI.

Boracic acid .....	47.95
Sesqui-oxide of iron .....	36.26
Water .....	14.02
Magnesia, lime, and loss .....	1.77
	<hr/>
	100.00

## LARDERELLITE.

Named from Count Larderell, is a hydrated borate of ammonia, found in the lagoons of Tuscany. It occurs in small crystalline rhomboidal plates. It is a rare mineral, never found in quantities sufficient to have any commercial value.

## ANALYSIS BY BECHI.

Boracic acid .....	68.556
Ammonia .....	12.734
Water .....	18.325
	<hr/>
	99.615

## BORACITE.

This mineral occurs crystallized and massive; color, white, gray, yellow, and green, streak white, fracture conchiconchoidal, uneven; sub-transparent, translucent. The massive variety which is found at Stassfurt, Prussia, under the name of *stassfurtite*, is white and hard, resembling fine grained marble; vitreous luster, inclining to adamantine; hardness, 7; specific gravity, 2.83, 2.98; pyroelectric; soluble in acids. The crystals, which are isometric or tetrahedral, have the following composition ( $3\text{MgO } 4\text{BO}_3 + \frac{1}{2} \text{Mg Cl}$ ):

Boracic acid .....	62.33
Magnesia .....	27.03
Chlorine .....	7.91
Magnesium .....	2.73
	<hr/>
	100.00

The massive variety contains sometimes six per cent of water. The boracite crystals found in the kainite beds at Stassfurt are soft and form a slimy mass with water.

The massive variety gives water in a closed glass tube; fuses in the blowpipe flame easily to a white crystalline glass, coloring the flame at the same time distinctly green; with oxide of copper on charcoal, colors the flame azure blue; soluble when powdered, in dilute hydrochloric, sulphuric, and nitric acids, found at several localities in Europe, notably at Stassfurt, Prussia, associated with salt, gypsum, and anglesite. It is reported also in Turkey, as shown by the following extract from a consular report; but as borate of lime is given as a synonym, there is some doubt as to the character of the mineral mentioned. A reference to the description of pandermite will show that the locality, if not the mineral, is the same:

[August, 1881.]

## MINES AND MINERALS OF TURKEY.

[Report by U. S. Consul-General HEAP, of Constantinople.]

## BORACITE (BORATE OF LIME).

This is found at Moulreh, near Yeddis, on the Asiatic side of the sea of Marmora, where one mine has been in operation for six or seven years, and another has recently commenced delivery. The present annual yield is 4,000 to 5,000 tons, of which 4,000 tons are exported to France, where it is worth from \$75 to \$87 per ton, delivered; the freight from Kaloninie, where it is usually shipped, ranging from 30s. per ton for sailing-vessels to 21s. per steamers. The first cost of boracite is very little.

## HYDROBORACITE

Is a mineral which resembles gypsum. It is represented by a single specimen in a collection of minerals in Europe.

The following analysis is by Hess, who first noticed it :

Boracic acid .....	49.92
Lime .....	13.30
Magnesia .....	10.43
Water .....	26.33
	<hr/>
	99.98

This mineral may be distinguished from gypsum by its fusibility.

#### SZAIBELYTE

Is a rare borate of magnesia found in nodules in gray limestone in Werksthal, Hungary. It is named from Szajbelyi, who first noticed it. Its occurrence in limestone is interesting in connection with the theory that rock formations contain borax minerals in very large quantities.

The following analysis is by Stromeyer :

Boracic acid .....	36.66
Magnesia .....	52.49
Water .....	6.99
Chlorine .....	.49
Sesquioxide iron .....	1.66
Silica .....	.20
	<hr/>
	98.49

#### TOURMALINE

Is a mineral almost invariably found crystallized, of all colors, from opaque black to nearly or quite transparent colorless. The usual colors are: *black* (schorl), *red* (rubellite), *blue* (indicolite), *green* (crysolite), *honey yellow* (peridot), *colorless* (achroite).

All the tourmalines contain boracic acid from three to ten per cent. This mineral has never been worked for boracic acid, but is probably a source of that acid in nature, resulting from the decomposition of rocks containing it. (See the description of Tuscan lagoons under head of *Boracic Acid*.) The following analysis, selected from many, is given as an example of the general composition of tourmaline:

Silica .....	36.71
Boracic acid .....	6.49
Alumina .....	36.00
Binoxide of manganese .....	6.14
Sesquioxide iron .....	7.14
Magnesia .....	2.30
Lime .....	.80
Soda .....	2.04
Potash .....	.38
Fluorine .....	2.00
	<hr/>
	100.00

#### DATOLITE

Is a silicate of lime, containing from eighteen to twenty-two per cent of boracic acid. It is found in trappean rocks—gneiss, diorite, and serpentine. It has been mentioned elsewhere as a probable source of boracic acid resulting from the decomposition of rocks.

#### DANBURITE

Is a rare mineral, as far as known; containing twenty-seven per cent of boracic acid. It is found at Danbury, Conn., in dolomite.

## AXINITE,

Another rare mineral, contains from two to six per cent of boracic acid.

## SUSSEXITE

Is a newly discovered hydrated borate of manganese and magnesia, found with franklinite and other minerals in Sussex County, New Jersey. The following analysis is by Brush:

Boracic acid.....	31.89
Oxide of manganese.....	40.10
Magnesia.....	17.03
Water.....	9.59
	<hr/>
	98.61

## CHEMISTRY.

For forty-eight years after the discovery by Baron, the base of boracic acid remained unknown. Crell nearly found it in 1800, when he published a statement that boracic acid was the oxide of a substance resembling carbon. Davy repeated the experiments of Crell, but without obtaining the same results. In 1807 he submitted boracic acid to the action of a powerful galvanic battery, and obtained a black substance at the negative pole. But to Gay, Lussac, and Thenard belong the honor of first isolating the element boron, which is now known to be the base of boracic acid. The decomposition was made by fusing potassium with boracic acid in a copper tube.

Modern chemists have added much to our knowledge of boron and its compounds. Until the invention of the oxyhydrogen blowpipe, many substances were assumed to be infusible which now yield to its powerful action.

In 1837 Gaudin fused alumina into crystals resembling rubies and other precious stones of which alumina is the base. In 1847 Ebelmen, the manager of a Sevres porcelain factory, noticed that boracic acid sometimes volatilized in his furnaces. He commenced experimenting with boracic acid and alumina, which resulted in his obtaining shining crystals of extreme hardness, which he supposed to be oxide of alumina, but which were probably boron.

It is well known that carbon assumes three forms or conditions, which are "graphite," "charcoal," and the "diamond," or, as it would be expressed scientifically, *Graphitoidal*, *Amorphous*, and *Adamantine*. Wöhler and Deville have made elaborate experiments on boron, and found that it likewise exists in three forms like carbon, to which it exactly corresponds. Graphitoidal boron is obtained by subjecting a mixture of fluoborate of potassium with alumina to a high temperature. The amorphous form is prepared by strongly heating boracic acid with a small quantity of alumina, and boiling the residue in hydrochloric acid. It is a dull olive-green powder.

Adamantine boron is produced by submitting boracic acid and alumina in a charcoal-lined crucible, to a temperature at which nickel melts. Crystals of boron result, which are found imbedded in metallic aluminium. Some of the crystals are red; others yellowish. They are all extremely hard—almost as much so as the diamond itself. Corundum yields to the superior hardness of these



crystals. If this substance could be produced cheaply, it might be substituted for the diamond for certain mechanical purposes.

Boron is among the least plentiful of the non-metallic elements. When freed from water, boracic acid forms a colorless, transparent, brittle glass, which fuses at a red heat; does not volatilize alone, but with water or alcohol at a high temperature it is partly volatilized. If fused in a platinum crucible and allowed to cool, cracks are formed, during which a vivid light is seen, even in the daytime. In solution, it reddens litmus paper slightly, and its mixture with sulphur burns with a green flame.

Hydrate of boracic acid is formed by heating crystals of boracic acid above  $100^{\circ}$  centigrade, when they lose a part of their water. All the borates, except those of ammonia, potash, soda, and lithium, are insoluble in water, or difficultly so.

The borates are not decomposed by ignition, with the exception of those with alkaline bases. The solutions are colorless, and all (even the acid salts) give an alkaline reaction.

#### BORATE OF ALUMINA

Is formed when a solution of borax is poured into one of common alum. It forms white pearly scales, sparingly soluble in water.

#### BORATE OF AMMONIA.

There are several compounds of this nature. Quadroborate is prepared by saturating a warm solution of caustic ammonia with boracic acid. As the solution cools slowly, this salt crystallizes out in clear irregular six-sided prisms. The biborate is prepared as above, but with excess of ammonia. During the process the temperature rises, and on cooling right rhombic octahedrons form. Cotton goods saturated with solution of borate of ammonia and dried are rendered non-inflammable.

#### BORATE OF BARYTA.

Chloride of barium throws down in solutions of the borates, if not too dilute, a white precipitate of *borate of baryta*, which dissolves in acids and in solutions of ammonical salts. This precipitate, from solutions of the neutral borates, has the formula  $(\text{BaO BO}_3 + \text{aq.})$ , and from the acid borates  $(3\text{BaO}, 5\text{BO}_3 + 6 \text{aq.})$

#### BORATE OF BISMUTH

Is a white, very heavy powder, insoluble in water. Its preparation is not given in the text-books.

#### BORATE OF CADMIUM

Is a white powder, difficultly soluble in water, which falls when solutions of borax and sulphate of cadmium are mixed. It has the following composition :

Oxide of cadmium .....	72.115
Boracic acid .....	27.885

100.000

## BORATE OF CHROMIUM.

*Borate of chromous oxide* is obtained by mixing solutions of borax and protochloride of chromium, a pale blue precipitate, soluble in free acids.

To produce the *borate of chromic oxide*, borate of ammonia is precipitated with sesquichloride of chromium. It is a pale green powder.

## BORATE OF COBALT.

A reddish white powder obtained by the double decomposition of borax and chloride of cobalt, which may be fused to a beautiful blue glass. Oxide of cobalt fused with boracic acid yields a similar compound.

## BORATE OF COPPER.

Solution of borax poured into a solution of sulphate of copper produces a voluminous pale green precipitate of borate of copper, slightly soluble in water, which may be fused to an opaque green glass.

## BORATE OF IRON.

The *protoborate* is obtained by precipitating protosulphate of iron with borax. It is a pale yellow powder.

The *per borate* is an insoluble yellowish powder, vitrifiable at a high heat, which precipitates when solutions of per sulphate of iron and borax are mixed.

## BORATE OF LEAD.

One hundred and twelve parts of oxide of lead fused with twenty-four parts of boracic acid yields a soft yellow glass which is a borate of lead. It may be also produced in the form of a white flaky powder by precipitating a lead salt with borax. This precipitate fuses to a transparent glass and has the following composition:  $\text{PbO} + 2\text{BO}_3$ .

## BORATE OF LIME.

Borate of lime occurs in nature as ulexite, cryptomorphite, priceite, pandermite, colmanite, etc. In fact, there seems to be a strong affinity between boracic acid and lime. It may be prepared artificially by pouring a solution of borax into one of lime water. Borax precipitates lime salts, also, if they are not too dilute. These precipitates have the general properties of the natural borates of lime.

## BORATE OF MAGNESIA.

There are several borates of magnesia: 1. Tri-borate; 2. Monoborate; 3. Four thirds borate; 4. Ter borate.

1. Obtained by boiling solution of sulphate of magnesia with borax and washing thoroughly. At first it is gelatinous, but becomes white and solid, slightly soluble in water.

2. Aqueous solution of sulphate of magnesia and borax, boiled

together until they become turbid, and rendered clear by cooling, are set aside for some months, when crystals of the salt form.

3. Occurs only in nature as *boracite*.

4. Hydrate of magnesia in excess is boiled with boracic acid and water, filtered and evaporated; a crystalline crust forms, which is soluble in seventy-five parts of cold water.

#### BORATE OF MANGANESE

Precipitates as a white powder when borax and proto-sulphate of manganese, both in solution, are mixed. Care must be taken that there is no magnesia present as an impurity, for the borate of manganese is soluble in solution of magnesia.

The borate of manganese has been found to be a most excellent drier for paints, oils, and varnishes, and is coming into general use in the arts for that purpose. As manganese and borax are abundant and cheap in California, there seems to be no reason why it should not be extensively manufactured in the State. This subject is well worthy of the attention of some of our idle men and boys. Oil is boiled with the usual precautions, slowly at first, as water may be present; when so hot that it is certain that the water has been wholly driven off, the heat is increased. When sufficiently boiled, the borate of manganese is mixed with a little hot oil in a small vessel and added by degrees to the kettle, stirring all the while. When thoroughly mixed the kettle is covered and allowed to cool. There is no arbitrary rule for the quantity of drier to be used, as the requirements are not always the same. But three pounds of borate of manganese to 100 gallons of linseed oil has been used in practice and published.

#### BORATE OF MERCURY.

The proto-borate is obtained by mixing solutions of proto-nitrate of mercury and borax, and evaporating the solution. The result is a mass of small shining crystals.

#### BORATE OF NICKEL.

Borax throws down from solution of nickel salts a pale, apple green, precipitate of borate of nickel, insoluble in water, but soluble in sulphuric, hydrochloric, and nitric acids. It may be fused to a glass, of a hyacinth color.

#### BORATE OF POTASSIUM.

The *boride* obtained by heating the elements together in chemical proportions, has been examined, and found to be a mechanical mixture, and not a chemical compound.

The *borate* is formed when boracic acid and dry carbonate of potash are strongly heated together. It is fusible at a white heat; difficultly soluble in water, from which it does not crystallize.

The *biborate* is obtained by supersaturating carbonate of potash with boracic acid at a boiling heat; solution of caustic potash is added until the liquid is alkaline, when it is set aside to crystallize; the crystals are slightly alkaline to the taste, redden turmeric paper,

swell with heat like borax, then fuse to a transparent colorless glass, and dissolve readily in hot and cold water.

#### BORATE OF SILVER.

Nitrate of silver produces, in concentrated solutions of neutral borates, a white or slightly yellow precipitate of borate of silver ( $\text{AgO BO}_3 + \text{HO}$ ); in concentrated acid solutions a similar precipitate ( $3 \text{ AgO}, 4 \text{ BO}_3$ ). Dilute solutions of the borates give, with the same reagent, a precipitate of oxide of silver. All of these precipitates are soluble in nitric acid and in ammonia.

#### BORATE OF STRONTIA.

Borax in solution gives a precipitate with neutral salts of strontia. The precipitate is a white powder soluble in one hundred and thirty parts of boiling water; it dissolves also in a cold aqueous solution of hydrochlorate or nitrate of ammonia.

#### BORATE OF TIN

Is an insoluble white powder which fuses to a gray slag. Very little is known about it.

#### BORATE OF URANIUM.

To produce it, a solution of a uranic salt is precipitated with one of borax. It is light yellow in color, and sparingly soluble in water.

#### BORATE OF ZINC.

Aqueous solutions of sulphate of zinc and borax, when mixed together, throw down borate of zinc as a white powder, insoluble in water, but soluble in aqueous solution of boracic acid. It becomes yellow when ignited and fuses into a solid, compact, opaque slag.

#### BORATE OF ZIRCONIA

Is a precipitate formed by mixing solution of a salt of zirconia and borax. It is a white insoluble powder.

#### BROMOBORACIC ACID.

When vapors of bromine are passed over an ignited mixture of vitrified boracic acid and charcoal, a colorless gas is formed, which gives off white fumes in contact with moist air.

#### CHLORIDE OF BORON.

Chlorine gas is passed over perfectly dry boron, ignited in the large part of tube of glass or porcelain. The gas which forms is collected over mercury, and the free chlorine removed by agitation with mercury. It is a colorless gas, which gives off dense white vapors in contact with moist air.



## FLUORIDE OF BORON

Is a colorless gas, incombustible, and not a supporter of combustion. It has a pungent odor. In contact with moist air it forms a white cloud. It is formed by gently heating one part of vitrified boracic acid with two parts of fluorspar and twelve of concentrated sulphuric acid in a leaden vessel. Great care should be taken in its preparation, as the gases are poisonous.

## IODIDE OF BORON.

Vapors of iodine are passed over an ignited mixture of boracic acid and charcoal. A small yellow sublimate forms, which is probably iodide of boron; but of this there seems to be some doubt.

## SULPHIDE OF BORON

Forms when boron is heated to redness in a vapor of sulphur. It is a white opaque substance.

## FORMULÆ USEFUL IN CALCULATION.

Element.	Symbol.	Atomic Weight.
Boron .....	B .....	11.
Sodium .....	Na .....	23.
Oxygen .....	O .....	8.
Hydrogen .....	H .....	1.
Calcium .....	Ca .....	20.
Carbon .....	C .....	6.

## COMPOUNDS.

Boracic acid, anhydrous. $\text{BO}_3 =$ atomic weight .....	35
Boron .....	31.43 per cent
Oxygen .....	68.57 per cent
	100.00
Boracic acid, crystallized. $\text{BO}_3 + 3\text{HO} =$ atomic weight .....	62
Boracic acid .....	56.44 per cent
Water .....	43.56 per cent
	100.00
Borax, anhydrous. $\text{NaO } 2\text{BO}_3 =$ atomic weight .....	101
Soda .....	30.70 per cent
Boracic acid .....	69.30 per cent
	100.00
Borax, crystallized, prismatic. $\text{NaO } 2\text{BO}_3 + 10\text{HO} =$ atomic weight .....	191
Boracic acid .....	36.65 per cent
Soda .....	16.23 per cent
Water .....	47.12 per cent
	100.00
Borax, crystallized, octahedral. $\text{NaO } 2\text{BO}_3 + 5\text{HO} =$ atomic weight .....	146
Boracic acid .....	47.94 per cent
Soda .....	21.23 per cent
Water .....	30.83 per cent
	100.00

Ulexite, $2\text{CaO}, \text{NaO}, 5\text{BO}_3 + 10\text{HO} =$ atomic weight .....	352
Boracic acid .....	49.5 per cent
Lime .....	15.9 per cent
Soda .....	8.8 per cent
Water .....	25.8 per cent
	<hr/> 100.0

Carbonate of soda, anhydrous. $\text{NaO}, \text{CO}_2 =$ atomic weight .....	53
Soda .....	58.49 per cent
Carbonic acid .....	41.51 per cent
	<hr/> 100.00

Carbonate of soda, crystallized. $\text{NaO}, \text{CO}_2 + 10\text{HO} =$ atomic weight .....	143
Soda .....	21.67 per cent
Carbonic acid .....	15.39 per cent
Water .....	62.94 per cent
	<hr/> 100.00

## EXAMPLES SHOWING THE USE OF THE FORMULÆ.

Let it be required to determine how much crystallized borax can be made from a certain quantity of anhydrous boracic acid, say 74 pounds.

As the percentage of boracic acid in prismatic borax (36.6) is to 100 so is 74 to the unknown quantity.

$$\frac{74 \times 100}{36.6} = 202 + \text{pounds.}$$

The borax equivalent of borate of lime may be calculated as follows:  
Percentage of boracic acid in—

Borax .....	36.6
Ulexite .....	49.5

$$36.6:100::49.5:\text{unknown quantity.}$$

$$\frac{49.5 \times 100}{36.6} = 135.2 +$$

Therefore the boracic acid in 100 pounds of ulexite, if combined with soda and water, would yield 135.2 pounds crystallized prismatic borax.

## ASSAY OF BORAX.

Simple tests serve to detect the usual foreign substances contained in borax. When pure it should dissolve in twelve to twenty-four parts of cold water to a clear solution without color or residue. A sample heated to fusion should leave a residue weighing fifty-three per cent, nearly. If adulterated with nitrate of potash it will deflagrate when thrown on burning coals. If alum is present as an impurity, its solution will react acid to litmus paper. Borax is often degraded by admixture of phosphate of soda, sometimes to the extent of twenty per cent, in which case its solution will give a yellow precipitate upon addition of molybdate of ammonia mixed with excess of nitric acid. Lime is indicated by a white precipitate, which falls when carbonate of soda is added to the solution. This precipitate dissolves in dilute hydrochloric acid with effervescence. Sulphate of soda and chloride of sodium (common salt), the natural impurities, are indicated, the former by a precipitate with chloride of barium in the presence of free acid, and the latter by the formation of a white curdy precipitate with nitrate of silver in the presence of free nitric acid. The latter precipitate is soluble in ammonia and is reproduced on the addition of an acid.

If to a solution of boracic acid, or an alkaline borate, hydrochloric acid is added to slight acid reaction, and a slip of turmeric paper half dipped into it and dried on a watch-glass at  $212^{\circ}$  Fahrenheit, the dipped portion shows a peculiar red tint; this reaction, which is delicate, must not be confounded with similar colors obtained from other substances; to avoid which, experiments should be made with pure solutions, carefully prepared, to educate the eye.

The flame test has been described elsewhere.

Borax may be determined volumetrically. For this assay a solution of sulphuric acid must be prepared, in which an exact chemical equivalent of the acid shall be contained in each litre. This acid solution, called "normal sulphuric acid," must be carefully preserved in a well stoppered bottle, as on its purity and uniform strength depend the accuracy of the results. An equivalent of the borax to be assayed (or rather what would be an equivalent if it were pure) must then be dissolved in distilled water.

Now if both solutions contain exact equivalents, they would neutralize each other if poured together. In a like manner, if a tenth of each solution were mixed they would neutralize each other. The tenth of a litre is a convenient measure for the assay, because it contains 100 cubic centimeters (C.C.). If 100 C.C. of the acid solution neutralized the tenth of an equivalent of borax in solution, it would be evident that the sample was pure. If 80 C.C. only were required, the sample contains eighty per cent of borax. In other words, each C.C. of the acid solution represents one per cent of crystallized borax in the sample.

When litmus is added to a solution of borax, only a purple red color is seen while any borax remains undecomposed; but, upon adding sulphuric acid, at the instant that the last atom of soda is changed to sulphate, a light red color appears.

Upon these reactions, the volumetric assay is based.

It has been shown elsewhere, that the chemical equivalent of crystallized prismatic borax is 191. One tenth of this weight—19.1 grammes of the borax—is dissolved by shaking in cold water; 250 to 300 cubic centimeters will be required. The solution must not be filtered.

This solution is placed in a clean beaker, solution of litmus added until a deep color is imparted to the fluid. Normal sulphuric acid is then dropped in from a burette, graduated to 100 C.C. and tenths, until the color suddenly changes to a bright red. The first test may be made somewhat carelessly, as it will only be an approximation. The beaker is then washed out, and the operation repeated; this time with greater care. The result will be nearly correct. A third experiment will serve to verify the result. The reader should refer to some practical work on chemistry for description of the apparatus and method of making the test solutions. *Sutton's Systematic Handbook of Volumetric Analysis*, third edition, is one of the best.

Only borax can be estimated by this method. The determination of boracic acid in minerals and other substances, is extremely difficult, and can hardly be explained without an elaborate description, which may be found in text-books on analytical chemistry. In the volumetric method described above it is customary to deduct 0.5 C.C., to correct for the excess of sulphuric acid required to develop the red color in the assay.

## USES OF BORAX AND BORACIC ACID.

The consumption of boracic acid and its salts is only limited by the supply. It is very largely used in the manufacture of pottery and earthenware as a glaze. In 1820, Mr. Wood, of Liverpool, applied boracic acid to the glazing of pottery, which has continued, with increasing consumption, to the present time.

The following mixtures are published. For common English porcelain:

Feldspar.....	45 parts
Silica.....	9 parts
Borax.....	21 parts
Flint glass.....	20 parts
Nickel.....	4 parts
Minium.....	12 parts
	<hr/>
	111 parts

For figures and ornaments:

Feldspar.....	45 parts
Silica.....	12 parts
Borax.....	15 parts
Flint glass.....	20 parts
Nickel.....	4 parts
Minium.....	12 parts
	<hr/>
	108 parts

The glaze is made by melting the ingredients together, and afterwards grinding them with water, into which the ware is dipped and dried. The articles are first partially burned, in which form they are called "biscuit."

Large quantities of borax are consumed in the potteries at Trenton, New Jersey; East Liverpool, Ohio; Philadelphia, and Cincinnati, and will eventually be used in prospective potteries in our own State.

Borax has lately been extensively applied to the manufacture of porcelain-coated iron ware, known as "granite ware."

Boracic acid is used in the manufacture of certain varieties of glass and in "strass," which is the base of artificial gems named after the inventor, Strass of Strassburgh, who lived in the seventeenth century, and who was the first to make artificial gems of this character.

The following is the composition of strass:

Pure silix.....	300 parts
Potash.....	96 parts
Borax.....	27 parts
White lead.....	514 parts
Arsenic.....	1 part
	<hr/>
	938 parts

All the ingredients must be pure, specially the borax, which must be prepared from pure boracic acid. Tincal is not suitable.

The mixture is put into a Hessian crucible, and kept at the highest heat of a pottery furnace for twenty-four hours. The longer it is kept in a state of fusion the clearer and more homogeneous it will be when cooled. It is used by lapidaries for imitating diamond, topaz, and other white gems. For colored gems various metallic oxides are added in proportions only learned by experience. The coloring mat-



ter must be in the finest powder, and not only very intimately mixed, but the mixture must be very strongly heated, the heat must be long continued, and the cooling gradual.

It is stated in Parke's Chemical Essays that four ounces of borax and one ounce of pure fine white sand will make a pure glass, so hard as to cut common glass like the diamond.

The following formula is given of the brilliant greenish yellow glass of Sevres :

Silica .....	19.32
Protoxide of lead .....	57.64
Soda .....	3.08
Boracic acid .....	7.00
Protoxide of iron .....	6.12
Oxide of zinc .....	2.99
Antimonic acid .....	3.41
Potash .....	.44
	100.00

Vitrifiable pigments for glass staining and encaustic tiles are rendered fusible by admixture of borax. The following formulæ are given :

1. One part sand, three parts litharge, one third part borax. The borax must be fused in a platinum crucible and poured into water, and, when cold, ground fine.
2. One part sand, two and three quarters parts litharge, three eighths part borax. Heated as in No. 1.
3. One part sand, two parts litharge, one fourth part borax. Heated as in No. 1.
4. One part sand, three parts minium, one eighth part borax. Prepared as in No. 1.
5. Six parts white sand, washed, and heated to redness, four parts yellow oxide of lead, one part borax glass, one part saltpeter.
6. One part sand, two parts litharge, three quarters parts borax glass.
7. Eight parts white quartz sand, washed and calcined, four parts borax glass, one part saltpeter, one part white chalk.

In the art of enameling, borax is also largely used as a flux.

Borax has the property of dissolving the metallic oxides, which makes it useful in soldering metals. It renders the surfaces to be joined clean, so that the solder "runs" and fills the joint between them. For this purpose, as well as in welding iron, the octahedral is the most desired, as, containing less water, it sooner settles down quietly on the work. In soldering small articles, the borax is rubbed on a slab of slate with water; and the mixture put on with a camel-hair brush.

The same property is taken advantage of in blowpipe chemistry, to determine the presence of certain metals which may be in the substance under examination. A loop is prepared on the end of a thin platinum wire, in which borax is melted in the blowpipe flame; a small quantity of the substance in a fine powder is then introduced by wetting the borax bead and touching it to the powder. The bead is again subjected to the flame; first in the outer, and then in the inner flame, and allowed to cool while being closely observed.

## BLOWPIPE REACTIONS.

	OUTER FLAME.		INNER FLAME.	
	Hot.	Cold.	Hot.	Cold.
Yellow ---	Vanadic acid. Sesqui-oxide of iron. Oxide of lead. Ter-oxide of bismuth and of antimony.	----- ----- ----- -----	Tungstic, titantic, vanadic, and molyb- dydic acids.	----- ----- ----- -----
Red -----	Oxide of chromium. Sesqui-oxide of cerium.	Oxide of nickel. ----- -----	----- ----- -----	Oxide of copper. ----- -----
Violet ---	Sesqui-oxide of manganese. Oxide of cobalt containing manganese.	----- ----- -----	----- ----- -----	----- ----- -----
Blue-----	Oxide of cobalt. -----	Oxide of cobalt. Oxide of copper.	Oxide of cobalt. -----	Oxide of cobalt. -----
Green ---	Oxide of copper. -----	Sesqui-oxide of chromium. -----	Sesqui-oxides of iron, chromium, and uranium. -----	Vanadic acid. Sesqui-oxides of iron, chromium, and uranium.

Borax has great deterative properties and is very useful in the laundry. The washerwomen of Holland and Belgium, so celebrated for their fine and white linen, have used borax as a washing powder for many years. They add borax in the proportion of half a pound to ten gallons of boiling water. For washing laces, cambrics, and even woolen blankets and other goods, it will be found very useful. It is also a valuable cosmetic, rendering the skin soft, and it is claimed it will prove a preventive and even a cure for certain skin diseases. It is an excellent shampoo, without any admixture except water, and is perfectly harmless. For cleaning brush and comb it will be found very useful. It is so essential to the toilet that a bottle of it should be kept always ready, prepared as follows:

A quantity of refined borax is shaken up in a bottle with water until no more will dissolve. The solution is then poured off into a clean bottle and half the quantity of water added, and both mixed by shaking. If not clear it must be left some time to stand and the clear portion poured off, or better still, filtered through paper. In this condition it may be added to a basin of water, used as a mouth wash, and other ways as described.

*In medicine*, according to the United States Dispensatory, borax is a mild refrigerant and diuretic. It is a remedy for nephritic and calculous complaints dependent on an excess of uric acid. Externally it is used in solution as a wash in scaly eruptions, and for other diseases.

Borax and boracic acid are used to render cream of tartar more soluble. The formula given in the French codex is as follows:

Four hundred parts cream of tartar, and 100 parts of boracic acid are dissolved in a silver basin with 2400 parts of water at a boiling heat. The solution is kept boiling until nearly all the water is evaporated. The heat is then moderated and the mixture stirred. When it has become very thick it is removed in portions, which are flattened in the hand, well pounded, and powdered. This is soluble cream of tartar.

A solution of borax is used as a gargle for sore throat and in colds, and it has been found effective in cases of epizooty in horses. In 1873, experiments were made in San Francisco which gave favorable results. The doses were four ounces daily, given pulverized in the food.

In hot climates a cooling drink is said to be prepared with bicarbonate of soda, tartaric acid, and borax. This statement wants confirmation.

In 1878 Smith Bros. sold 20,000 pounds of borax to Chicago consumers, to be used in preserving and canning beef.

Borax is used as a mordant in calico printing and in dyeing, and as a substitute for soap in dissolving gum out of silk; in solution as a wood preservative, and in the manufacture of soap. A varnish made by boiling one part of borax with five parts of shellac is used in stiffening hats. With caseine borax forms a substance which is used as a substitute for gum. A solution of borax in water may be mixed with linseed oil and used for cheap painting.

Borax is extensively used in assaying, in the metallurgy of ores, and in the smelting of copper, and it is said to be an excellent insecticide, being especially obnoxious to cockroaches.

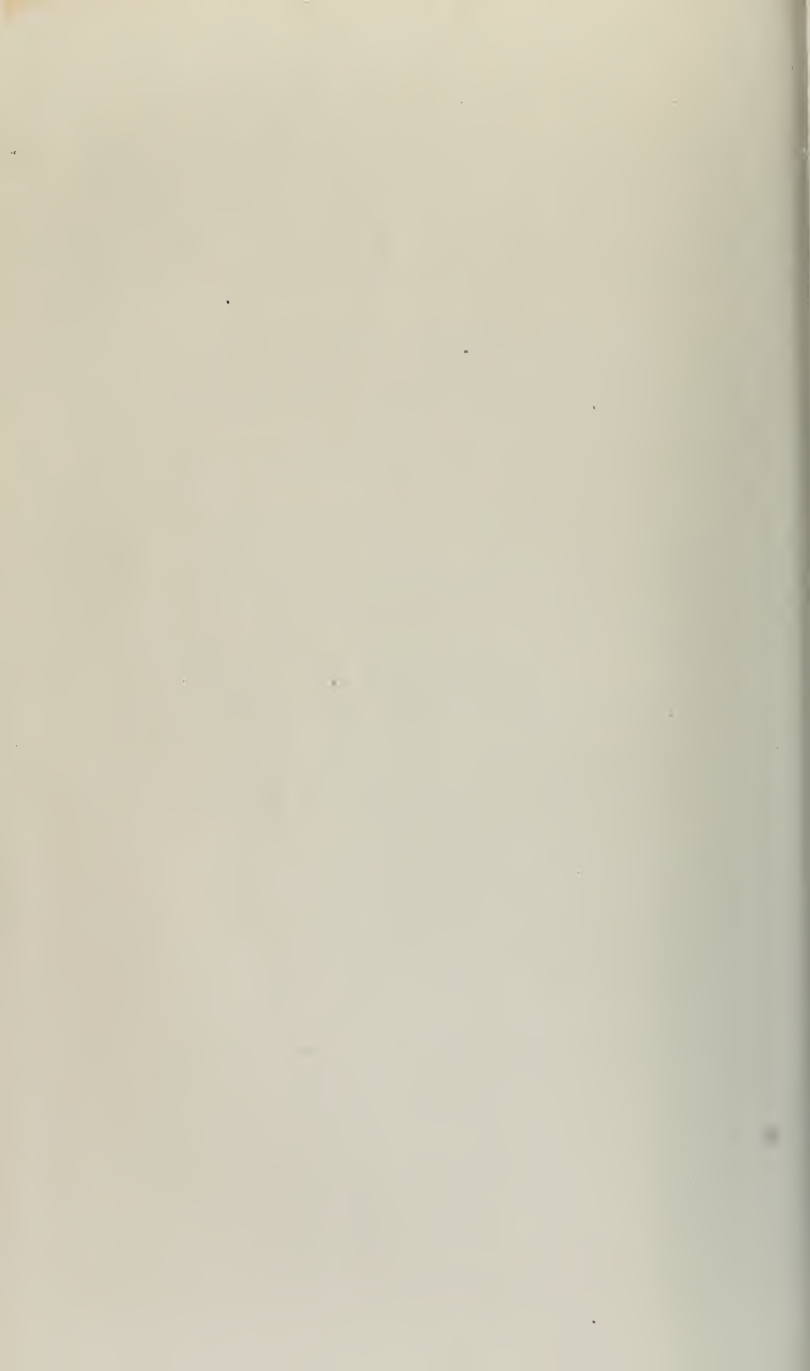
There are probably other uses to which it has been put, and no doubt new applications will be found for it if the production should increase.

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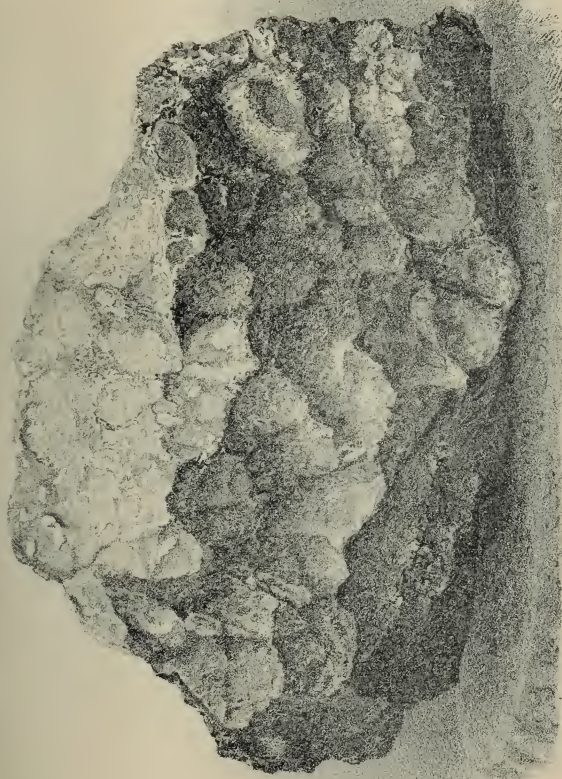
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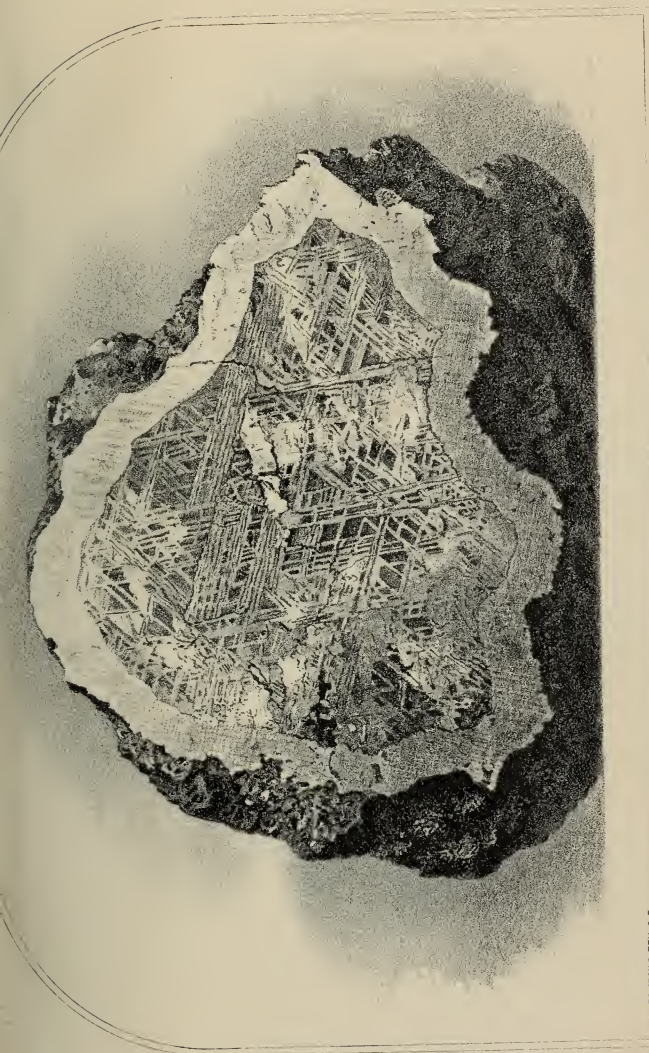


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